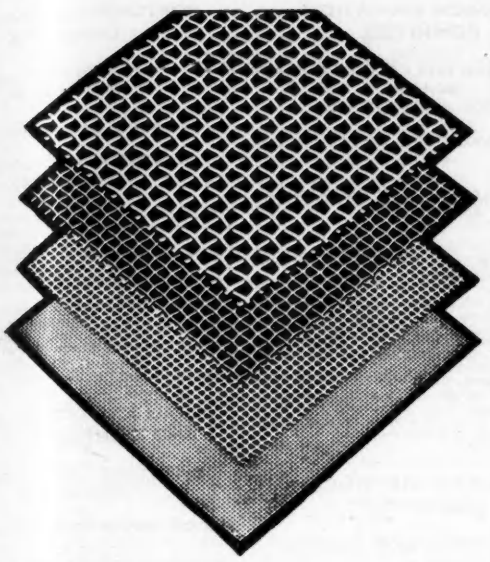

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For Filtering it plays a vital part in many kinds of mechanical equipment, and in the processing of liquids.

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THE ENGINEER

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PRINCIPAL CONTENTS

(Complete contents on page 634)

Institution Collaboration 634

Stress Concentrations at Holes in Rotating Discs ... 618
(H. G. EDMUNDS)

Institution of Civil Engineers' Presidential Address 620

Development of the Steam Turbine 623
(F. DOLLIN)

Mechanised Cultivation and Harvesting of Sugar Beet 638

Development of Reheat for Gas Turbines 631
(J. L. EDWARDS)

Soviet Rocket Development 635

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All letters intended for insertion in 'The Engineer or containing questions should be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever can be taken of anonymous communications. No undertaking can be given to return drawings or manuscripts: correspondents are therefore requested to keep copies.

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Advertisements received by Mid-day Tuesday will appear in the issue of Friday the same week. Orders must be accompanied by a remittance.

INDEX TO ADVERTISERS—PAGE 147

PUBLIC APPOINTMENTS

THE NEW SOUTH WALES UNIVERSITY OF TECHNOLOGY

WOLLONGONG TECHNICAL COLLEGE

ASSOCIATE PROFESSOR IN MECHANICAL ENGINEERING

Vacancy for ASSOCIATE PROFESSOR in MECHANICAL ENGINEERING, Wollongong Technical College, New South Wales, Australia.

The University invites applications for appointment as Associate Professor in Mechanical Engineering, tenable at Wollongong Technical College. Salary £A1950 per annum.

The appointee, who must have high academic qualifications, will be responsible for the University courses in Mechanical Engineering, comprising at present part-time Degree and Diploma Courses. He will be eligible, subject to medical examination, to contribute to the New South Wales Superannuation Fund, which will provide a pension of £A1014 per annum.

Heavy industries, particularly steelmaking, in the area are expanding, and the successful applicant will be expected to show a keen interest in research problems associated with them.

New mechanical engineering laboratories are being built.

The University reserves the right to fill the position by invitation.

First class shipping fares to Sydney of appointee and family will be paid.

Further particulars may be obtained from Professor A. H. Willis, Head of the School of Mechanical Engineering, N.S.W. University of Technology, Sydney.

Five copies of applications, with testimonials and other supporting documents, should be lodged with the Agent General for New South Wales, 56/57, Strand, London, W.C.2, before 21st December, 1954, also one copy of application should be forwarded by air mail to the Bursar, N.S.W. University of Technology, Broadway, New South Wales, Australia, by the same date. E6377

THE NEW SOUTH WALES UNIVERSITY OF TECHNOLOGY

SYDNEY, AUSTRALIA

SCHOOL OF MECHANICAL ENGINEERING

ASSOCIATE PROFESSOR IN PRODUCTION ENGINEERING

Vacancy for ASSOCIATE PROFESSOR in PRODUCTION ENGINEERING.

The University invites applications for the position of Associate Professor in Production Engineering in the School of Mechanical Engineering. Salary £A1950 per annum.

Applicants should possess a high academic qualification and have extensive production experience. The appointee will be required to take charge of the Diploma and Certificate Courses in Production Engineering, under the general direction of the Head of the School of Mechanical Engineering ; to direct a programme of expansion to meet industry's needs for trained production engineers, and to initiate and direct research into production engineering problems.

The appointee will be eligible, subject to medical examination, to contribute to the New South Wales Superannuation Fund, which will provide a pension of £A1014 per annum.

First class shipping fares to Sydney of appointee and family will be paid.

The University reserves the right to fill the position by invitation.

Further particulars may be obtained from Professor A. H. Willis, Head of the School of Mechanical Engineering, Sydney.

Five copies of applications, with testimonials and other supporting documents, should be lodged with the Agent General for New South Wales, 56/57, Strand, London, W.C.2, before 21st December, 1954, also one copy of application should be forwarded by air mail to the Bursar, N.S.W. University of Technology, Broadway, New South Wales, Australia, by the same date. E6376

THE NEW SOUTH WALES UNIVERSITY OF TECHNOLOGY

NEWCASTLE UNIVERSITY COLLEGE

ASSOCIATE PROFESSOR IN MECHANICAL ENGINEERING

Vacancy for ASSOCIATE PROFESSOR in MECHANICAL ENGINEERING, Newcastle University College, New South Wales, Australia.

The University invites applications for the position of Associate Professor in Mechanical Engineering, Newcastle University College. Salary £A1950 per annum.

Applicants must be Graduates with high academic qualifications and extensive industrial experience. The Associate Professor will be required to take charge of professional courses in mechanical engineering at Newcastle under the general direction of the Head of the School of Mechanical Engineering in Sydney ; to take a close interest in local engineering industry and to initiate and direct research into engineering problems.

The appointee will be eligible, subject to medical examination, to contribute to the New South Wales Superannuation Fund, which will provide a pension of £A1014 per annum.

First class shipping fares to Sydney of appointee and family will be paid.

Further particulars may be obtained from Professor A. H. Willis, Head of the School of Mechanical Engineering, Sydney.

The University reserves the right to fill the position by invitation.

Five copies of applications, with testimonials and other supporting documents, should be lodged with the Agent General for New South Wales, 56/57, Strand, London, W.C.2, before 21st December, 1954, also one copy of application should be forwarded by air mail to the Bursar, N.S.W. University of Technology, Broadway, New South Wales, Australia, by the same date. E6375

THE NEW SOUTH WALES UNIVERSITY OF TECHNOLOGY

SYDNEY, AUSTRALIA

SCHOOL OF CIVIL ENGINEERING

ASSOCIATE PROFESSOR

Vacancy for ASSOCIATE PROFESSOR, School of Civil Engineering.

The University invites applications for the vacant position of ASSOCIATE PROFESSOR in CIVIL ENGINEERING. Salary £A1950 per annum.

The Associate Professor will be responsible to the Head of the School of Civil Engineering for teaching and research in the general field of materials, including concrete technology, building materials and soil mechanics. Good facilities for research are available.

Applicants should possess high academic qualifications and have had good industrial experience, or be interested in industrial problems.

The University reserves the right to fill the position by invitation.

The appointee will be eligible, subject to medical examination, to contribute to the New South Wales Superannuation Fund, which will provide a pension of £A1014 per annum.

First class shipping fares to Sydney of appointee and family will be paid.

Further particulars may be obtained from Professor C. H. Munro, Head of the School of Civil Engineering, Sydney.

Five copies of applications with testimonials and other supporting documents should be lodged with the Agent General for New South Wales, 56/57, Strand, London, W.C.2, before 21st December, 1954, also one copy of application should be forwarded by air mail to the Bursar, N.S.W. University of Technology, Broadway, New South Wales, Australia, by the same date. E6374

SURREY EDUCATION COMMITTEE

KINGSTON TECHNICAL COLLEGE

FASSETT ROAD, KINGSTON-UPON-THAMES

(AMENDED ADVERTISEMENT)

HEAD OF THE ENGINEERING DEPARTMENT

Applications are invited for the post of HEAD OF THE ENGINEERING DEPARTMENT.

Candidates should possess a good Honours Degree. Teaching and industrial experience is essential, research experience desirable. Salary, Burnham Scale for Grade IV, £1365 by £25 to £1515, or Grade V, £1515 by £25 to £1665, Head of Department, plus London allowance £36 or £48, according to qualifications and experience.

Applications from candidates in reply to the previous advertisement will be considered on receipt of a note to this effect.

Further particulars and application forms obtainable on receipt of stamped, addressed envelope from the Principal. Completed forms to be returned not later than 4th December.

KINGSTON TECHNICAL COLLEGE

FASSETT ROAD, KINGSTON-UPON-THAMES

LECTURER IN AERONAUTICS

Applications are invited for the post of LECTURER in AERONAUTICS in the Engineering Department. The appointment is for a specialist in aerodynamics. Applicants should be Graduates with appropriate industrial experience. Teaching experience desirable. Salary scale £965 by £25 to £1065 plus London allowance (£36–£48, according to age).

Further particulars and application forms obtainable (on receipt of stamped, addressed envelope) from the Principal. Completed forms to be returned as soon as possible. E6378

BUCKINGHAMSHIRE EDUCATION COMMITTEE

AYLESBURY SECONDARY TECHNICAL SCHOOL

Headmaster : E. B. EATON

TEACHER OF ENGINEERING WORKSHOP PRACTICE AND TECHNOLOGY

Required, as soon as possible, TEACHER OF ENGINEERING WORKSHOP PRACTICE AND TECHNOLOGY to Intermediate City and Guilds Machine Shop Engineering standard. A knowledge of elementary metrology is essential.

Application forms may be obtained from the Headmaster, Aylesbury Secondary Technical School, Walton Road, Aylesbury, to whom they should be returned within fourteen days of the appearance of this advertisement. E6381

WEST RIDING COUNTY COUNCIL

SHIPLEY ART AND TECHNICAL INSTITUTE

ASSISTANT TEACHER (GRADE A)

Applications are invited for the post of ASSISTANT TEACHER (GRADE A) for engineering and allied subjects in part-time day and evening classes. Candidates should possess a Higher National Certificate in Engineering, or a City and Guilds Full Technological Certificate, and have had some teaching experience.

Salary in accordance with the Burnham Technical Report, 1954.

Forms of application obtainable from the Divisional Education Officer, Town Hall, Shipley, to whom they should be returned within 14 days of the appearance of this advertisement. E6361

NORWICH EDUCATION COMMITTEE

THE NORWICH CITY COLLEGE AND ART SCHOOL

IPSWICH ROAD, NORWICH

Principal : FRANK BRIERS, B.Sc., D.Phil. (Oxon), F.R.I.C.

ASSISTANT LECTURER IN MECHANICAL ENGINEERING

Wanted, for 1st January or as soon as possible thereafter, ASSISTANT LECTURER IN MECHANICAL ENGINEERING.

Duties include teaching in National Certificate Courses and in Craft Courses. Applicants should be Graduates or hold good technical qualifications, and should have had some industrial experience.

Salary according to the Burnham Technical Scale, Grade B (£525, rising by £25 to £820 per annum, with approved allowances).

Application forms, which may be obtained from the Director of Education, City Hall, Norwich, on receipt of a stamped, addressed envelope, should be returned to the Principal within a fortnight of the date of appearance of this advertisement.

29th October, 1954. E6380

NOTTINGHAMSHIRE EDUCATION COMMITTEE

MANSFIELD TECHNICAL COLLEGE

Principal : R. F. BEATON, B.Sc. (Eng.), Wh.Sch.

ASSISTANT, GRADE B

Applications are invited for the post of ASSISTANT, Grade B, in electrical engineering subjects Applicants will be expected to teach to the level of the Higher National Certificate, and should hold suitable qualifications. Adequate industrial experience is expected and preferably some experience of teaching.

The salary is in accordance with the Burnham Technical Scale for Assistants, Grade B, £525 by £25 to £820 per annum. Additions may be made to the scale for certain qualifications and study training. The position on the scale is determined by previous teaching and industrial experience.

Forms of application may be obtained from the Divisional Education Officer, Education Office, Market Place, Mansfield, to whom they should be returned within two weeks of the appearance of this advertisement.

J. EDWARD MASON,
Director of Education.

County Hall,
Nottingham,
1st November, 1954. E6387

CITY OF LEICESTER

EDUCATION COMMITTEE

COLLEGE OF TECHNOLOGY AND COMMERCE

Principal : R. E. WOOD, M.Sc., F.Inst.P.

SENIOR LECTURER

Applications are invited for the post of SENIOR LECTURER in the School of Commerce to teach work measurement in various industrial courses and to develop a new training course for work study engineers. Degree or relative professional qualification, and sound industrial experience in all aspects of work measurement, essential. Salary, Burnham Technical Scale, £1065 by £25 to £1215 per annum.

Further details and forms of application may be obtained from the Registrar at the College, to whom completed forms should be returned within one week of this announcement.

ELFED THOMAS,
E6347 Director of Education.

MINISTRY OF SUPPLY

ENGINEER

Ministry of Supply requires ENGINEER in London to supervise planning and progressing production of small/medium specialised mechanical components involving widely varying processes in sheet steel, non-ferrous metals and light alloys. Liaison with experimental branches. British of British parents. Recognised engineering apprenticeship and A.M.I.C.E. or Mech.E. or E.E., or exemption qualifications, sound experience manufacture light/medium mechanical equipment, familiar modern techniques and processes. Salary : within £1000–£1320. Not established, but opportunities to compete for establishment may arise.—Application forms from M.L.N.S., Technical and Scientific Register, 26, King Street, London, S.W.1, quoting C601/54A. E6337

BRITISH RAILWAYS

PADDINGTON

ESTIMATOR

British Railways have a vacancy at Paddington for an ESTIMATOR experienced in steelwork design, workshop procedure and the preparation of contract documents. Post offers permanency and carries the advantages of superannuation and rail travel privileges. Apply, giving age, experience, &c., to Civil Engineer's Office, Paddington, London, W.2. E6189

PORTSMOUTH EDUCATIO COMMITTEE

CITY OF PORTSMOUTH COLL TECHNOLOGY

Principal : W. TAYLOR, D.Sc., F.I

LECTURER IN MECHANICA ENGINEERING

Applications are invited for the appoi LECTURER IN MECHANICAL ENGIN

Candidates should possess a Universit Engineering and have had industrial The ability to teach Applied Thermod Degree standard is a desirable, but not a qualification.

Salary is in accordance with the Burn nical Report (£965 by £25 to £1065).

Forms of application and further deta obtained from the Registrar.

E. G. BARNARD,
E6348 Chief Educatio

WIGAN AND DISTRICT MI AND TECHNICAL COLL

DEPARTMENT OF MECHANIC ENGINEERING

SENIOR LABORATORY STEWARD

Applications are invited for a post as LABORATORY STEWARD (MALE) Department of Mechanical Engineering College. Duties will commence as soon a Candidates should hold a Higher National in Mechanical Engineering or similar qua Salary on the scale £440 to £520 a year.

Further particulars and application for sent by the undersigned on receipt of a addressed foolscap envelope. Last date of applications, Monday, 15th Novem Applications not on the form provided disregarded.

E. C. SN
Pr

26th October, 1954.

METROPOLITAN WATER BO

APPOINTMENT OF CIVIL ENGIN ASSISTANTS

CIVIL ENGINEERING ASSISTANT in salary scale £680–£730, (b) one in £490–£650, are required in the Chief Department on the permanent pensionable

For (a) applicants must be Corporate M the Institution of Civil Engineers. Exp civil engineering and building construc supply of water from wells will be an adva

For (b) applicants must have passed or be from passing Sections A and B or Final Par of the examinations of the Institution Engineers.

Commencing salary according to age qualifications and experience. Further p of the conditions of appointments will be interviews or on request. Applicatio particulars of technical education, qualifica experience, together with the names and of two persons to whom reference may should be addressed to the Chief Engi should reach the Board's offices not later November, 1954. Canvassing disqualifies ship to any member, officer or employe disclosed.

W. S. CHEVAL
Clerk of the
Metropolitan Water Board, New Riv
Rosebery Avenue, London, E.C.1.

SOUTHERN ELECTRICITY

SENIOR DRAUGHTSMAN (C ENGINEERING)

No. 1 (Southall) Sub-Area, Waterlo Uxbridge. Salary N.J.B., Schedule "D" (£595 7s. to £704 11s. per annum, inclusive allowance). N.J.B. conditions of service.

Applicants should have had training and e in building construction and the design of and reinforced concrete structures, and be preparing drawings, and making calculation

The successful candidate will be require tribute to the B.E.A. and Area Boards' tion scheme, if eligible.

Applications on forms obtainable from Area Secretary, 2/6, Windmill Lane, Middlesex, and returned to him in envelope endorsed not later than November 19, 1954.

WHITTINGTON HOSPIT

HIGHGATE WING

ASSISTANT ENGINEER

ASSISTANT ENGINEER required at Wh Hospital, Highgate Wing, Dartmouth Pa N.19. Applicants should be over 25 year and have completed practical training in engineering and preferably possess an National Certificate for Mechanical Engi equivalent. The successful candidate will be to reside within a reasonable distance hospital. Inclusive salary £455 by £15 to £ Applications, stating age, qualifications ence, together with names and address referees, to Secretary, Archway Group H Cholmeley Park, N.6, by 15th November.

THE ENGINEER

NOVEMBER 5, 1954

"Comet" Court of Inquiry

THE public inquiry into the "Comet" disasters was resumed on Thursday last week at Church Hall, Westminster, an adjournment having been made for members of the court to visit Farnborough and see the salvaged skeleton "Comet" and film records of some of the experimental work undertaken there. The wisdom of "Comet" aircraft being reintroduced into service after the crash at Elba before salvage operations there had been concluded and in the light of the earlier "Comet" disaster at Calcutta, was questioned. On this issue Air Chief Marshal Sir Frederick Bowhill, who is chairman of the Air Safety Board (which is advised technically by the Air Registration Board), was questioned by Mr. J. M. Shaw (for relatives of some of the victims). Mr. Shaw referred to the Indian Court of Inquiry on "Comet ALYV," which found that structural failure had occurred during a squall of unusual severity. He then went on to read a minute sent by the Air Safety Board to the Minister of Transport concerning the Elba crash. This minute said that no satisfactory account could be found for that crash, and that some factor other than a storm might have caused the crash at Calcutta, which might possibly be common to both disasters. In the course of his reply to Mr. Shaw and Sir Hartley Shawcross on this issue, Sir Frederick maintained that everything "humanly possible" had been done to ensure safety. On Friday a suggestion by Mr. Jablonsky that the "Redux" bonding process had led to a primary failure was discussed. Mr. Ripley, head of accident investigation at the R.A.E., maintained that the "Redux" joints where the primary failure of the fuselage had occurred were in good condition. When the court was resumed on Friday Sir Arnold Hall referred to the tremendous effort and cost of the investigations and the imperative need to discover what was happening to "Comet" aircraft. This task he described as being "desperately difficult," and on its resolution he said he drove many of his staff to work a 120-hour week. He later suggested that all new types of aircraft should be tested to destruction in the manner that the "Comet" had at Farnborough.

Joint Iron Council

ON Tuesday evening, November 2nd, the Joint Iron Council held its annual banquet at the Dorchester Hotel, London. The toast of "The Council" was proposed by Lord Layton, chairman of the Consultative Assembly of the Council of Europe. After pointing out how nearly one-half of the exports of this country now come from the iron and steel industry itself and metal-using industries as compared to only one-quarter in 1913, he went on to discuss whether the British iron, steel and coal industries should be more closely associated with those of Western Europe. He felt it would be a serious handicap to the London agreement if economically Britain stood aside from the Continent; our industries drew their raw materials from much the same places as did European industries; Britain could hardly hope wholly to divorce itself from association with the iron and steel industry of the Rhine Basin. The steel and coal pool was attempting to create a single great market in Europe similar to that existing in America. If it was successful there must be great social and economic repercussions. He believed success was more likely to be achieved if British industry contributed from its own experience. The president, Mr. N. P. Newman, replied. In responding to the toast of "The Iron and Steel Board," proposed by Sir Frederick Scopes, Sir Archibald Forbes, chairman, the Iron and Steel Board, referred to the unique experiment conducted in this country of setting up a board to supervise an industry operating under private enterprise. Some degree of supervision had applied for over twenty years, and the idea of supervision had commended itself to a majority within the industry itself. The board had nothing to do with executive management. Its function was to supervise general policy, and it owed a duty to consumers as well as producers. He preferably hoped that the industry would not again become a cockpit of political controversy. Mr. S. W. Martin proposed the toast of "The Guests" and Lord Bruce of Melbourne replied.

Europe's Oil Production and Consumption

THE Organisation for European Economic Co-operation has received from its oil committee an interim report setting out some of the main trends in Europe's oil industry. It says that the maximum potential distillation capacity in European refineries rose from 82·1 million tons a year at the end of 1952 to 100·4 million tons a year at the end of 1953, and that by the end of 1956 the figure is expected to reach 112·3 million tons. Thus, the rapid expansion of refining facilities which formed part of the European Recovery Programme may be regarded as having ended last year, and, if current plans are realised, the next few years will be a period of continuing but slower expansion. Apart from the refinery extensions and constructions, the completion of which is forecast by the end of this year, there is mention in the report of the increases in capacity scheduled for completion in 1955 and 1956. These, it is stated, consist of a slight increase of distillation capacity in the United Kingdom (1500 tons per stream day) and an appreciably larger distillation increase in France (about 8000 tons per stream day). This latter capacity increase, the committee says, is explained by the consumption increase in metropolitan France and by the policy of supplying from French refineries a growing part of the overseas territories of the French Union where the consumption of petroleum products is rapidly increasing. The committee has estimated that last year the inland consumption of oil in Europe was 64·9 million tons, and it expects that by 1956 the annual inland consumption figure will reach 77·5 million tons. One comment made by the committee is that the years 1946 to 1951 were a period of abnormally rapid industrial reconstruction and economic growth and that the increase in the demand for oil was correspondingly great.

Railway Reorganisation

ON Monday last the House of Commons debated the Railways Reorganisation Scheme as set out in the White Paper published in July last. The debate was opened by the Parliamentary Secretary to the Ministry of Transport and Civil Aviation, Mr. Hugh Molson, who described the functions of the area boards proposed for the management of the railways. He said that policy in the future, as in the past, as it applied to the railway system as a whole, would continue to be decided by the British Transport Commission, but the Commission would be considering concrete problems arising in the areas. There would be a two-way movement of ideas between the Commission and the area boards. The Minister of Transport and Civil Aviation, Mr. John Boyd-Carpenter, wound up the debate. In the course of his speech he said that the chairman of the British Transport Commission hoped to present a plan for the re-equipment and modernisation of British Railways before the year ended. That plan would be of "a drastic and exhaustive nature, based upon a reassessment of the future role of the railways in this country." The Minister added that a great deal of careful preparatory work had been necessary and that the plan was now before the Commission.

International Pressure Die Casting Conference

THE first International Pressure Die Casting Conference arranged by the Zinc Alloy Die Casters Association and the Zinc Development Association which was held in London last week concluded with a dinner on Wednesday, October 27th. In responding to a toast to the die casting industry proposed by Sir Walter Puckey, Mr. F. G. Woollard, the chairman of the Zinc Alloy Die Casters Association, said how successful this first conference had been. Its principal objects had been to consolidate friendships between the manufacturers in this country and their Continental associates; to improve die casting techniques, and to promote wider appreciation of die castings in industry. Mr. Woollard pointed out that the automobile industry took more than half the output of die castings, and greater efforts should be made to extend their use. In this direction the market for domestic goods offered great opportunities which should not be neglected, and by careful investigation die casting manufacturers could create new outlets for their products. A later speaker, the Earl of Verulam, said that the degree of international technical collaboration at the conference was impressive and such co-operation was good for any industry. He gave examples of how die casting manufacturers overseas were creating new markets by redesigning familiar domestic equipment on new and modern lines to suit production by die casting methods. Such measures were not easy and called for enterprise but they could be well repaid by results in extended markets. Monsieur C. A. Wahl expressed the appreciation of the many foreign visitors to the conference for the way in which they had been welcomed and for the interesting visits which had been so well arranged.

British Cast Iron Research Association

THE thirty-third annual report of the British Cast Iron Research Association, which has just been issued, reviews the Association's activities during the year ended June 30th last. It records that the membership continues to increase, and that at the end of the year the excess of current assets over current liabilities was £22,920, compared with £3440 at the end of the preceding year. The report says that the total capital expenditure for the year was £5609, and that the whole of the extensions envisaged in 1948 have now been completed. These include the erection and equipment of the chemical and spectrographic laboratories, the sands laboratories, provision for the operational research team, the foundry atmospheres team and the development department, and a block for heavy stores. The shell of the experimental foundry has been completed. About this the report comments that it has been recognised from the beginning that provision for equipping the experimental foundry, and for its operating costs, would require consideration during the quinquennial period which has just started. Meanwhile, the building is being used to accommodate part of the work of the foundry atmospheres team. That team, it is explained, is pursuing a programme of work on the elimination of dust from the knock-out section of foundries, an extensive schedule having been laid down to determine the critical air contours required to control dust plumes under widely varying shop conditions. Preliminary work has also been carried out in connection with the problem of external pollution of the atmosphere from cupola furnaces, which is, of course, a matter of considerable importance to foundries situated near to residential areas.

Stress Concentrations at Holes in Rotating Discs

By H. G. EDMUNDS, Ph.D., A.M.I.Mech.E.

In 1940 Teverovsky published a paper which described a photoelastic investigation of the stress concentrations at eccentric holes in flat rotating discs. The normal photoelastic method was employed, and the models were observed during rotation by means of a stroboscope. A compensator was used to measure the low fringe orders involved. The present article describes further tests which were made between 1947 and 1950 in the Engineering Laboratories of the University of Cambridge, using the frozen stress technique. Only twelve discs were tested, but the models were designed to facilitate a critical examination of Teverovsky's results.*

BETWEEN 1947 and 1950 tests were made in the engineering laboratories of the University of Cambridge to examine Teverovsky's determinations of stress concentrations at eccentric holes in flat rotating discs. The frozen stress technique was employed and the material used for the tests was Catalin 800, and the initial work consisted of an investigation of the considerable edge effects to which that material is liable. This investigation justified a method of correcting for edge effects whereby two identical models were prepared and tested. At every stage of preparation and test the two models were treated together in the same way, except that only one was loaded. Then the fringe order due to loading alone was determined by subtracting algebraically the fringe orders in the two models. (Simple algebraic subtraction is valid only along an axis of symmetry or at a free boundary.) Incidentally it was also found that time edge effects which developed in models prior to stress freezing had a negligible effect on the edge effect after freezing.

The stress-fringe value of the material and the speed of rotation were calibrated by spinning a rectangular specimen with each disc. One of these calibration pieces is shown in Fig. 1, and close by on the underside of the turntable may be seen the slot in which it was carried. The calibration piece extended beyond the turntable and exhibited a fringe pattern which depended upon the stress-fringe value of the material and the square of the speed of rotation. Approximate corrections were applied to the calibration in respect of changes of cross section due to lateral strain as well as the temperature of setting.

As regards the arrangements for spinning the models, it was evidently necessary that they should afford an accurate location and should allow the model to expand freely, but in addition a degree of flexibility was required so it was decided not to depend upon a central hole in the model either for location or drive. The arrangement finally adopted is illustrated in Fig. 1. In a turntable of 6in diameter three symmetrically placed recesses were machined, and in each recess a small disc was mounted on a ball race. The small discs were free to pivot upon the ball races, and each carried an eccentric pip $\frac{1}{16}$in diameter and $\frac{3}{32}$in high. Before assembly the small discs were statically balanced on their pivots. Thus, with three shallow, symmetrical holes in the model disc, the register of the pips in the holes provided the necessary location and drive, and it may readily be shown that the arrangement imposes no restraint on the expansion of the disc. Evidently there was a wide range within which the pitch radius of the locating holes could be chosen freely. Figs. 2 and 3 illustrate the quality of the fringe patterns and the smallness of the disturbance caused by the model carrying arrangements.

In both the earlier and the present series all the tests were made on flat discs which had a central bore as well as a number of eccentric holes. In any one disc the eccentric holes were of equal diameters and were positioned symmetrically on a single pitch circle. Fig. 4 illustrates the nomenclature used. Stresses in a disc having eccentric holes are denoted by p, whilst stresses in a similar disc without the eccentric holes are denoted by σ. Suffices r and θ refer to the radial and circumferential directions respectively, and numerical suffices refer to positions in the disc as shown.

Considering Teverovsky's work, it was found that the greatest stress in the region of an eccentric hole always occurred at position "3," and the stress concentration factor f_3 was defined as the ratio $p_{\theta 3}/\sigma_{\theta 3}$. He concluded that f_3 depended upon the stress ratio $\sigma_{r3}/\sigma_{\theta 3}$, and upon d/n, the ratio of the diameter of the holes to the circumferential length of the land between holes, and although the nature of the dependence was expressed graphically it appears that it may be interpreted thus :—

Within the limits

$$0<\sigma_{r3}/\sigma_{\theta 3}<1$$

and

$$0<d/n<1$$

$$f_3=p_{\theta 3}/\sigma_{\theta 3}=3-d/n-\sigma_{r3}/\sigma_{\theta 3}.$$

It may be seen that the variation of f_3 with the stress ratio is the same as that for an infinite plate under uniform "rectangular" stresses of magnitude $\sigma_{\theta 3}$ and σ_{r3}. In this respect, therefore, the solution appears a likely one for those regions of the disc which, being remote from the boundaries, are positions at which the stress gradients are small. Yet it is perhaps surprising that the solution reflects no variation of f_3 with either the magnitude or the sense of the stress gradients, and it is to be expected that any errors there may be in Teverovsky's solution are likely to be greatest for holes near the boundaries of the disc. As regards the variation of f_3 with d/n, it is possible to consider the kind of result that might be expected by considering a disc having eccentric holes of very small diameter. However, it will be argued later that for high values of d/n, that parameter alone is inadequate to describe the disc, and in order to facilitate a subsequent comparison

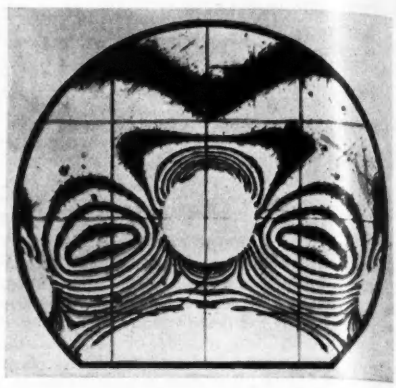


Fig. 3—Enlargement of area indicated in Fig. 2

* *Sov. Kotloturbo*, No. 11, Nov. 1940, pages 402–411.

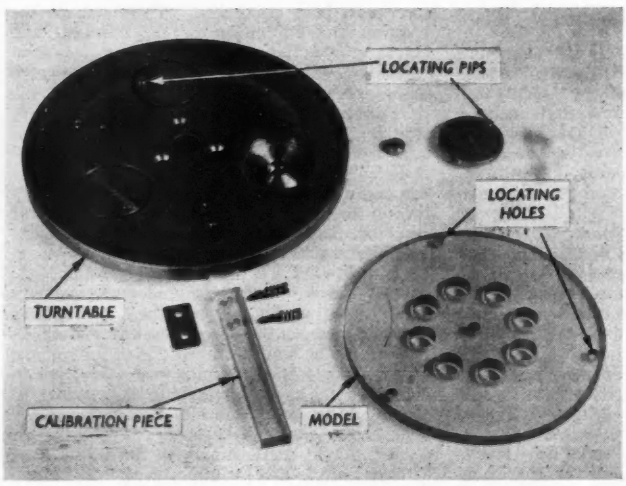


Fig. 1—Components of the apparatus for spinning the models

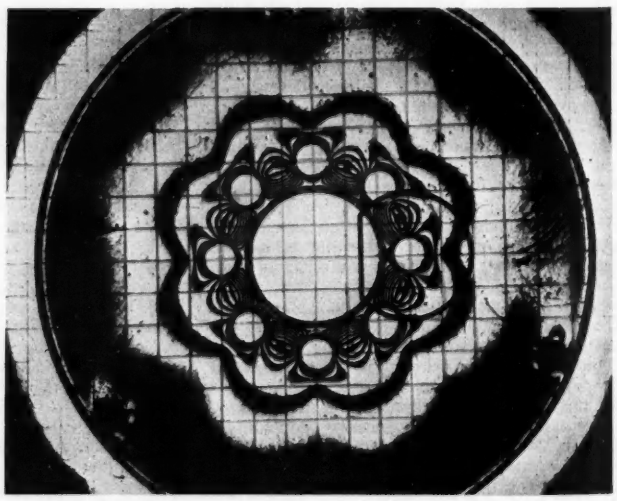


Fig. 2—Frozen stress pattern in a disc having eight eccentric holes

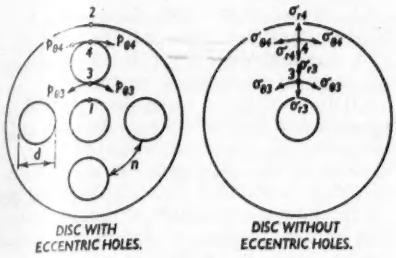


Fig. 4

with experimental results the disc will be assumed to have the following geometry :—

$$r_1/r_2=0\cdot232\ ;\ r_3/r_2=0\cdot632.$$

As mentioned above, it is to be expected from the infinite plate theory, and was confirmed by Teverovsky, that on discs having a single small eccentric hole (for regions remote from the boundaries at least)

$$f_3=3-\sigma_{r3}/\sigma_{\theta3}.$$

It may be calculated that for the disc specified above $f_3=2\cdot42$; i.e., when $d/n=0$ then $f_3=2\cdot42$. Now if d/n be increased by adding

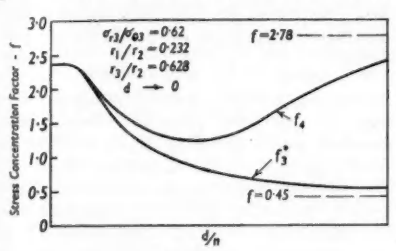


Fig. 5

further holes, it may be argued that interaction between the holes will be negligible until a certain value of d/n is reached (Teverovsky quoted $d/n\leqslant0\cdot25$), and it follows that f_3 should remain substantially constant while d/n increases from 0 to about 0·25. In addition the stress patterns for discs with single eccentric holes show that in regions somewhat removed from a hole the stresses are reduced on account of the hole. Thus it is to be expected that in the early stages of interaction the value of $p_{\theta3}$ and thus of f_3 is likely to fall as d/n increases above 0·25. Now consider the limiting case as d/n approaches infinity. The very large number

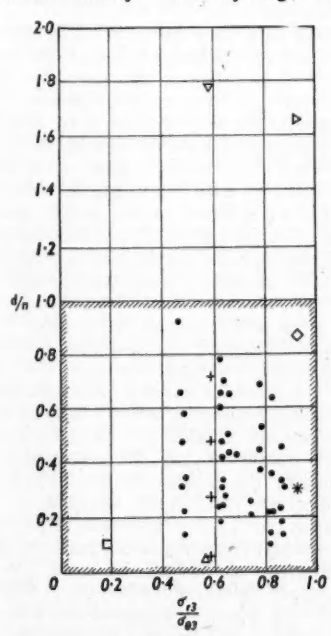


Fig. 6

of very small holes effectively affords a " smooth " separation of the disc at radius r_3, and thus the values of $p_{\theta3}$ and $p_{\theta4}$ may be calculated from simple theory by treating the parted discs separately. From this it is evident that when d/n is very large the value of f_3 does not essentially depend upon $\sigma_{r3}/\sigma_{\theta3}$, but rather upon r_1/r_2 and r_3/r_2, and it was for this reason that a particular disc was postulated at the beginning of the argument. For the disc specified it may be calculated that as d/n approaches infinity f_3 approaches 0·45 and f_4 approaches 2·78. Fig. 5 has been drawn up to illustrate the above discussion. It represents the manner in which f_3 and f_4 may be expected to vary with d/n when $r_1/r_2=0\cdot232$, $r_3/r_2=0\cdot628$, and $d\to0$.

Returning to the experimental results, the more important details of the new tests are listed in Table I. In Teverovsky's tests the ratio of the bore diameter to the disc diameter varied between 0·0723 and 0·333, whilst the ratio of the diameter of the eccentric holes to the disc diameter had values of 0·033, 0·05, 0·067 and 0·083. The values of the ratios d/n and $\sigma_{r3}/\sigma_{\theta3}$ at which the

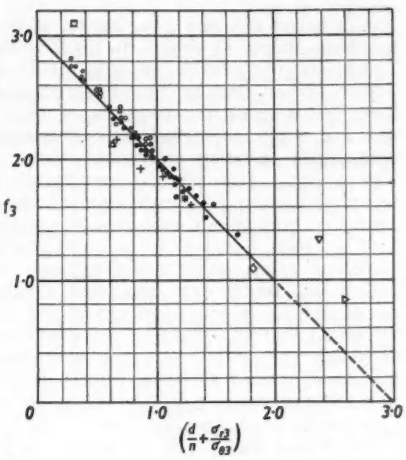


Fig. 8

hatching. From this diagram a picture is obtained of the degree of extrapolation implied in Teverovsky's results and also of the way in which some of the new tests are comparable with those of Teverovsky, whilst

TABLE I.—*Experimental Results of Frozen Stress Analysis on Twelve Rotating Discs with Eccentric Holes*

Model No.	Legend	r_1/r_2	Eccentric holes				$\frac{d}{n}$	$\frac{\sigma_{r3}}{\sigma_{\theta3}}$	$\frac{\sigma_{r4}}{\sigma_{\theta4}}$	f_3	f_4
			No.	Diam.	P.C.D.	$d/2r_3$					
1	—	0·233	None	—	—	—	—	—	—	—	—
2	+	0·232	2	0·247	3·015	0·056	0·055	0·58	0·54	2·17	2·30
3	+	0·231	8	0·247	2·998	0·056	0·271	0·58	0·54	1·93	2·15
4	+	0·233	12	0·248	3·018	0·056	0·470	0·58	0·54	1·86	2·01
5	+	0·234	16	0·248	3·028	0·056	0·715	0·58	0·54	1·62	1·90
6	△	0·231	1	0·416	2·756	0·092	0·051	0·56	0·57	2·13	2·18
7	*	0·045	3	0·440	1·804	0·101	0·304	0·92	0·87	1·69	2·0
8	◇	0·044	6	0·442	1·812	0·101	0·872	0·92	0·87	1·10	1·32
9	▽	0·233	24	0·247	3·011	0·056	1·780	0·58	0·54	1·33	1·59
10	▷	0·045	8	0·444	1·816	0·101	1·650	0·92	0·87	0·85	1·09
11	□	0·232	2	0·247	1·513	0·056	1·116	0·186	0·43	3·12	2·62
12	—	0·045	5	0·876	2·246	0·199	1·640	0·92	0·79	1·70	2·45

tests were conducted are represented graphically in Fig. 6. Teverovsky's tests are denoted by dots, whilst the present tests are indicated according to the legend in Table I. The limits within which Teverovsky's results were presented are indicated by cross

other tests were designed to extend the range covered.

Fig. 8 is a plot of f_3 against $[(d/n)+(\sigma_{r3}/\sigma_{\theta3})]$, and the straight line represents the relationship $f_3=3-d/n-\sigma_{r3}/\sigma_{\theta3}$.

The legend is the same as that used in

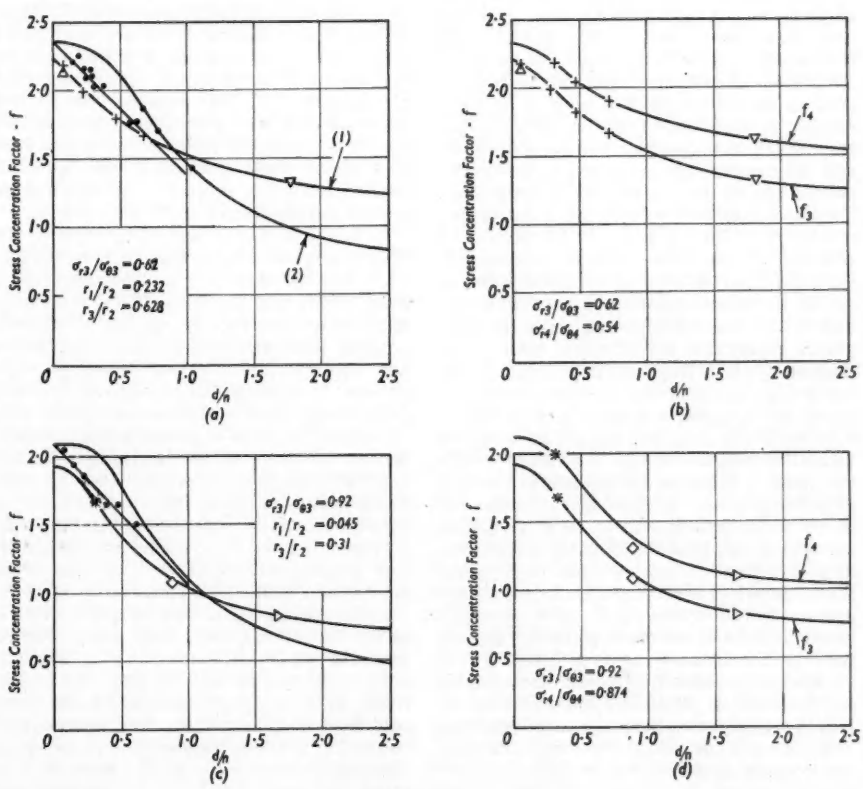


Fig. 7

Fig. 6, but in this case a further set of plots has been added, as shown by small circles. These are the results of tests made by Teverovsky on discs having a single eccentric hole. Comparing the two sets of results, tests 2, 3, 4 and 5 were made under conditions comparable in every way with those of Teverovsky. Test 6 was comparable as regards d/n and σ_{r3}/σ_{03}, but employed rather larger eccentric holes for which $d/2r_3$ equalled 0·092. Tests 7 and 8 were comparable in respect of $d/2r_3$, but employed values of d/n and σ_{r3}/σ_{03}, which were somewhat greater. In all the above tests it is considered that Teverovsky's results were corroborated to a satisfactory degree. Test 11, however, gave a value of f_3 which exceeded Teverovsky's by about 40 per cent of σ_{03}. The reason for this discrepancy is not certain, but it may be noted that in Test 11 the value of r_1/r_2 was 0·232, whereas Teverovsky's lower values of

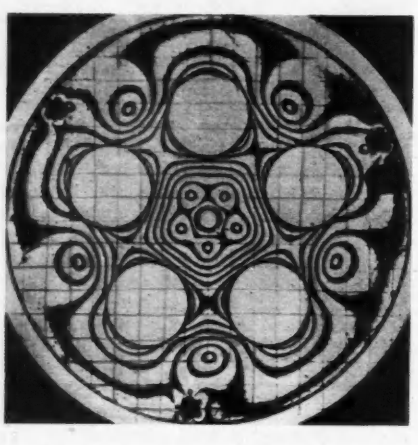


Fig. 9—Fringe pattern in model No. 12

$(d/n+\sigma_{r3}/\sigma_{03})$ were all obtained on discs in which r_1/r_2 was 0·333. From this it follows that the stress gradients $d\sigma_{r3}/dr$ and $d\sigma_{03}/dr$ were greater in Test 11, and the greater value of f_3 may be a reflection of this fact. It is also clear from tests 9 and 10 that Teverovsky's results may not be extrapolated to values of d/n greater than 1, but these two results are seen in better perspective in Fig. 7. For tests 2, 3, 4, 5, and 9 the values of σ_{r3}/σ_{03} may be taken as common and equal to 0·58, and the corresponding values of f_3 have been plotted against d/n to give line (1) in Fig. 7 (*a*). The dots refer to a number of Teverovsky's results in which σ_{r3}/σ_{03} varied between 0·61 and 0·66. For these tests the values of f_3 have been corrected to a standard value of $\sigma_{r3}/\sigma_{03}=0·58$, according to Teverovsky's own findings. The straight line through these points represents Teverovsky's result. All the above results may now be compared with curve (2), which is the type of result suggested by argument and represented in Fig. 5. Besides illustrating the comparative agreement between the results for values of d/n less than 1, this figure illustrates the danger of extrapolating Teverovsky's results for values of d/n greater than 1. In Fig. 7 (*b*) the curve of f_3 has been reproduced and a curve of f_4 has been added. It should be noted that although f_4 is greater than f_3, it does not necessarily follow that p_{04} is greater than p_{03}. Nevertheless, the present experiments did not confirm Teverovsky's finding that "3" is always the position of greatest stress. This contradiction is illustrated most clearly by Fig. 9, which shows that with large eccentric holes the position of greatest stress may not occur either at position 3 or at position 4. Figs. 7 (*c*) and 7 (*d*) show a second comparison similar to Figs. 7 (*a*) and 7 (*b*), between another set of Teverovsky's "corrected" results and the results obtained from tests 7, 8 and 10.

Conclusions

(1) It was not confirmed that the greatest stress always occurs at that point on the boundary of the eccentric hole which is nearest the centre of the disc, but for holes whose diameters were less than 10 per cent of the disc diameter the greatest stress did not exceed p_{03} by more than a few per cent. In the single instance of a disc in which d was 19·9 per cent of $2r_2$ and in which d/n was 1·64, the greatest stress was considerably greater than p_{03}, and it arose at two symmetrical positions between "3" and the pitch circle of the holes.

(2) Within the range $0<d/2r_3<0·1$ and $0<d/n<1$ and $0·4<\sigma_{r3}/\sigma_{r3}<1$, the later values of f_3 were somewhat lower than Teverovsky's, but were of comparable magnitude.

(3) For values of σ_{r3}/σ_{03} less than 0·4 it appears that Teverovsky's results may underestimate the stress concentration, but the amount of the discrepancy is uncertain. It may depend upon the ratio of the central bore diameter to the diameter of the disc, or, as that implies, to the closeness of the holes to the boundary of the disc.

(4) It appears that Teverovsky's results may not be extrapolated to values of d/n greater than 1, and it is argued that for high values of d/n the parameters used by Teverovsky are inadequate for a proper definition.

Institution of Civil Engineers

PRESIDENTIAL ADDRESS

Mr. David Mowat Watson, president of the Institution of Civil Engineers for the session 1954–55, delivered his presidential address on Tuesday, November 2nd. In the abstract from his discourse which we print below, Mr. Watson comments on the Institution's membership and affairs, continues with some remarks on the relationship between consultants and contractors, and goes on to give his views on some of the wider problems, both technical and administrative, facing the public health engineer to-day.

It is recorded in the annual report on the session 1837 printed in the very first volume of the Institution's *Minutes of Proceedings*, that the council "believes that the time is fast approaching, when a general conviction of the advantage which must result from the periodical meetings of the members of the same profession, will induce all scientific men to unite in advancing the great objects which the original projectors of the Institution had in view, and which the Council has constantly laboured to promote." In the same report two measures of the size of the Institution were given :—The one was a total membership of 252, comprising only forty-seven ordinary members, ninety-three corresponding members—the equivalent of our associate members—ninety-eight associates, and fourteen honorary members ; the other is taken from the published accounts for the previous year and shows the total expenditure for the year to have been £851 11s. 4d. To-day, our comparable figures are about 13,000 corporate members and about 7000 graduates and students, making a total of more than 20,000 and an annual expenditure of about £95,000.

It would be true to say that our aims and objects are the same to-day as they were in 1837, but the scope for prosecuting them is much wider and the work involved in their achievement is greater—perhaps infinitely greater. Our membership and organisation are incomparably larger, although that was to be expected, as the growth of civil engineering works demanded more civil engineers, but those engineers would not have become members of the Institution had not the Institution been wisely and properly controlled. On that, and on insistence on suitable education and training, rather than on the growth of our membership should we feel a sense of satisfaction in our status amongst the learned societies.

Although Sir John Rennie spoke in 1845 of the "deservedly high place our profession holds in public estimation" it is doubtful if the public of to-day are given the opportunity of forming an estimate of the place held by the civil engineer who is too often content to be just a back-room boy, of whom the public has never heard. His work is taken for granted ; he is too modest and does not seek recognition of the essential part he plays in inspiring, planning and working out all the pracucal details which eventually give place to the actual direction of the great sources of power in nature to the use and convenience of man. That we should blatantly advertise ourselves is an objectionable and an improper thought, but our Institution has given us some lead in how to make known with dignity some of our works. There is still need, however, for clear thinking to abolish all foolish assumption of modesty, untimely silence, and cloistered indifference.

The public do not know the heavy responsibility that rests on the engineeer in spending public money on capital works ; they do not realise that his lengthy processes of comparing many ways of doing even a simple job, assessing the life as well as the annual costs, is by no means a mechanical process. It is his experience and judgment which prompt him to recommend only one of the many schemes he has considered. Thereby he assumes the real, if not the nominal, responsibility.

In the early days the term "civil engineer" was an all-embracing designation for all non-military engineers and the scope of their activities was the wide definition of our Charter. The very magnitude of the subject led rapidly to the need for specialisation ; nowadays, the accumulation of experience and research with their considerable bibliography, combined with better technical education, has inevitably necessitated greater and greater specialisation as time has marched on. For convenience the term "civil engineer" has become more restricted in its meaning since our brothers in mechanical and electrical engineering founded their own institutions, but fundamentally, and in fact, this Institution remains available to all practising engineers who comply with our membership conditions. In more recent times confusion has been caused in the minds of the public by the formation of engineering institutions devoted in their interests only to departments of civil engineering—departments which are included in civil engineering as judged by even the most restrictive definitions of to-day. To make confusion worse confounded the very word "engineer" has become so wide in its use and so loosely applied that it is doubtful

if it has any value left. In 1922 the Institution obtained a supplemental charter empowering all its corporate members to call themselves "chartered civil engineers," and this had at least the merit of enabling the professional engineer to describe himself with the minimum of confusion. The term is perhaps not ideal, but it is the best available to us and its more common use would result in education of the public.

In the annual report on the session, 1838, Telford was quoted as having once said that "Judicious regulations are absolutely necessary in all societies, but I trust that in this the good sense of the members will always feel that manners and moral feeling are superior to written laws." We civil engineers claim that our education is wide and embraces many technical studies and subjects ; that our activities bring us into contact with the labourer, the craftsman, and the academician, the administrator, and members of other professions ; that our experience teaches us to be just, to weigh our facts, to avoid hasty decisions, to look at all points of view. Surely, if our claims are justified, we can govern our own behaviour, treat our fellows fairly, and comport ourselves with propriety in our personal and professional capacities. If we can, if we are all of one thought, if we all conform to the rulings of our own professional colleagues, then we can truly say that "manners and good feeling are superior to written laws." In our Institution we have written laws because every community must have a government of some kind, but the test of our behaviour is the frequency of infringement of those laws. The Council has a committee which is concerned only with professional conduct and contraventions of the Institution's written laws of conduct. I have served on that committee for a long time now and can say with pride that it is by far the lightest-worked committee of the Council. The alleged delinquencies are few, and the committee seldom has to meet.

The Contract System

There is to-day a working partnership between the professional engineer and the contractor, which is a relationship of which we can be proud. At times our points of view differ and in our enthusiasm we are ready to miscall one another with alacrity, but seldom with sincerity ; only occasionally do we differ seriously and have recourse to arbitration or the law courts. Our differences are resolved amicably enough and justice is done to our complaints of one another. Confidence between the two bodies has been established. To preserve it, however, the engineer throughout the administration of a contract between the employer for whom he is acting, either as a full-time salaried officer or as a consultant, and a contractor, must act with scrupulous fairness whether the result is for or against his own employer. His state of independence to judge fairly between employer and contractor must be unassailable, and any attempts to remove from his shoulders even a part of that great and honourable responsiblity should be resisted strenuously. The intervention of a third party would, I believe, wreck these conspicuously successful relations at the ultimate price of all public works. Too many of our public authorities are tending to bring into the administration of the contract other officials in addition to the engineer. That is deplorable and can only do harm in the long run, by destroying confidence, introducing unnecessary uncertainties, delaying settlements, and eventually raising costs. Obligation to be loyal to our heritage is heavy on us all but the duty to resist this interference, is squarely set on the shoulders of the professional engineer.

Just as the public works contractor of to-day has developed from the technically unqualified employer of labour, so have his tools changed beyond recognition from pick, shovel and wheelbarrow to mechanically operated machines of astonishing mobility, size and purpose. Their economic employment to lessen the cost of all operations is an important factor affecting the capital cost of all public works, but it is not possible for the engineer to take full advantage of it when he is designing, because he is then unaware of the identity of the successful tenderer. Had he been aware of it he might have adopted a design differing to some large or small extent. The desirability of public tendering is too well known to need comment, but is it beyond our ingenuity to evolve some system whereby the engineer can take full advantage of the facilities which will be available during construction and of the experience of the men who know best how to handle their own plant to get the best out of it ? Looking into the future it seems that the imperfectly informed may tend to favour "all-in bids" by contractors tendering on design as well as construction, and if so, they will thereby fall a prey to all the serious evils of competitive design. Overseas work affords some evidence that this is not an unfounded fear. That the merit of a design cannot be judged by cost is known by us so well that it is not worthy of mention, but, astonishing as it may be, it is not known by very many bodies who ought to know ; and we should help them to understand.

Public Health Engineering

So far I have thought of our profession in its widest application, but I turn now to the more limited sphere in which I have so long been engaged. Our point of view has understandably changed. In the early days the first problem came first, namely, to remove sewage from dwelling-houses and populated areas ; whereas to-day, with this difficulty solved, we concentrate more on the resultant difficulty of conservation of river water purity. Statistics of decrease in infectious disease, particularly water-borne disease, are used to show improvement in sanitary conditions as well as advance in medical practice, and formerly the emphasis was on those statistics ; to-day the focus of attention is on river pollution.

That great pioneer of sanitation and public health legislation, Edwin Chadwick, is recorded as having taken part in a discussion in the Institution more than once, but on one occasion he directed attention to several fundamental points. That was in 1865, when he took part in the discussion on Bazalgette's paper on the main drainage of London. He advocated rational drainage areas as defined by natural not artificial boundaries, self-cleansing sewers and drains, abolition of right-angled sewer junctions, better sewer discharge formulæ, and "since he had promoted the use of pipe sewers" he advocated them, though many had in the past been badly made and badly laid. But his contribution to the land treatment of sewage was the most stirring ; he is quoted as having said that the soil itself is the best storage reservoir, the best deodoriser, and the cheapest ; that the need was for self-cleansing sewers, quick discharge from the houses as well as from the streets ; that fresh sewage—not putrid at the outfall—has no smell. He went on, "Fresh sewage is too valuable to be thrown into the river to feed fish, and should be on the fields to feed men. A poetical French writer," he continued, "Victor Hugo, had said on this subject : 'These heaps of ordure in the corners of the streets—these cartloads of manure which go jolting along the streets at night—those horrible tubs of liquid—the pestilential flood concealed beneath the pavement—do you know what it all is ? It is the meadow in flower—the green herb—the wild thyme and clover—it is the abundance of game—it is the flocks of sheep and herds of cattle—it is the contented lowing of oxen in the evening—it is the scented hay and golden corn—it is the bread upon our table—it is the rich blood in our veins—it is health—it is enjoyment—it is life ; so it is ordained by that mysterious creation, which is transformation on earth and transfiguration in heaven. Give all this to the great crucible, and receive back abundance. The nutrition of plants is the food of man.'"

Water carriage of sewage was by no means readily accepted by engineers as the proper method of removal of sewage from dwellings ; long-drawn out and frequently recurring are the records in some of our early *Proceedings* when this principle was challenged and keenly debated. It was said, with some justice, that the problem was only moved from one end of the sewer to the other, where it was vastly larger and more complex in nature owing to the large volume of water involved. But the danger to public health was unquestionably moved from the urbanised areas to the watercourses, and land treatment, long practised in many places, came into greater prominence as the only proved method of purification of the sewage. That brought in its immediate wake the question of separating the settleable solids from the liquid sewage and for years there were intensive studies and lively discussions in the Institution about methods of separation, mechanical screening, chemical precipitation, and purely physical settlement in tanks.

It seems obvious to us to-day that the champions of water carriage of sewage should ultimately win the day, because we know now that by no other means can the largest amount of unclean matter be removed from a town in the shortest time. That is the engineer's duty, and although the method he employs to-day is unchallenged he might perhaps profit by stopping occasionally to satisfy himself that he is approaching as near to the perfect state as he can. Are we entirely satisfying our conscience ? Is the removal as efficient and complete as it should be ? No doubt we are approaching the ideal ; and the now stimulated acceptance of trade wastes, often of an obnoxious nature, into public sewers has in recent years acted as a spur to the cleaning up of industrial cities even if not directly of the actual dwellings. Do we remove and treat as much rain-water as we should ? Do we pollute watercourses with the washings of many impervious areas and call it, euphemistically, "surface water" ? Discharged from a system of sewers entirely separate from our foul sewers, this surface water enjoys immunity from the stigma of the word "sewage," but we know that on occasions it is equally objectionable. Are we entirely happy about those overflows from foul sewers coming into operation when rain causes the flow in the sewer to exceed a rate glibly described as "six times the dry-weather flow" ? Why six times ? And is "the dry-weather flow" not in itself rather an academic term inducive of argument ? Six times may be right, but are we always happy about it ? Is it not an empirical figure which may be wrongly applied ? We know that the

Royal Commission on Sewage Disposal arrived at that figure and recommended it as the result of much evidence and earnest consideration and we respect highly the monumental work of the Royal Commission, but do we perhaps shield behind it as a habit rather than as a considered decision specifically applicable to the individual case ?

Although sewage works have almost entirely superseded the old sewage farm, and occupy perhaps only a hundredth part of the area, there can be no doubt that our methods are still liable to undergo evolutionary, or even radical, change. Modern practice has been built up piecemeal over a period of many years ; trial and error, research, and economics having played their important parts, but it is very marked that the scientific knowledge brought to bear on the operation as well as on the design is very materially greater to-day than it was in the past. It is certain that the manager, the chemist, the biologist, and the engineer, separately or collectively, will introduce changes in practice just as they are collectively concerned in overcoming many of the operational troubles and imperfections. In sewage purification works design, therefore, less than in most branches of civil engineering, could it be claimed that a given design would long remain up-to-date.

For example, we follow long-established custom when we say that sludge disposal is the most troublesome part of the problem of sewage treatment. We have a greater choice of method of treatment of sludge at our command to-day than ever before, but we are constantly teased by the fundamental question of final disposal. Can the dried sludge in its final condition be usefully applied to the land and are economics completely reliable when we decide to dump it on land or at sea ? The cost of transport from sewage works to agricultural land is a serious drawback to utilisation on land, but money, and even labour values are fluid in a changing world. The absolute criterion is use or waste.

Mechanisation of sewage works has been gradual in the past fifty years. Manual operations of many kinds are now carried out by mechanical and electrical plant. For example, tank bottoms are now swept clear of sludge by machines while the tanks are still operating, whereas the tanks were formerly emptied and the floors cleaned by men pushing rubber squeegees. But in a world of changing values economics decided in favour of the machine. None of the many processes of the modern sewage purification works is now without its mechanical and electrical plant ; many of those processes are highly mechanised, and the value of such additional facilities has been taken advantage of to improve efficiency and control of plant. Consequently, sewage purification plant is to-day complicated to the extent of requiring mechanics and electricians in increasing numbers and the management must be better informed technically than was once necessary. Process supervision, too, is of a higher technical degree, and better control of plant is assured owing to the constant vigilance and work of chemists.

It is no accident that sewage works have become cleaner and tidier places during these transitions. Better education and higher living standards have led all men to develop and practice greater self-respect, and better working conditions follow. There need not now be any dirty jobs on sewage works and hence slovenliness amongst the men ; tidier thinking can therefore be reasonably expected, combined with greater working efficiency.

The public mind has passed beyond the early ideas that sewage disposal can be made to show a profit ; it has advanced so far as to recognise that efficiency and lack of offence are a moral as well as a legal obligation ; it is slower to realise that cleanliness, dignity, and general amenity as well as spit and polish play an important, if not an essential, part in the public service. There is no end to the details, the inclusion or exclusion of which may be debated as either extravagant on the one hand or niggardly on the other. Refinements in control and more complete recording of process facts apart, the answer to such questions must in many cases depend on common sense, psychology of the public, and of the men employed, as well as on judgment born of experience. Never should it be overlooked, however, that money spent on appearance may be wise expenditure. In some parts of Great Britain there is some difficulty in getting labour for sewage works and there are probably several reasons for that, but one of them will often be found to be that the sewage works are needlessly unattractive. Sewage works presenting an unpleasant appearance are more often said to cause smell nuisances than clean and tidy works.

Too little is known about the cost of sewage purification. The service is vital to Great Britain and the cost of it, though not vital, is of first importance to the ratepayer. Prior to the 1939–1945 war the Ministry of Health published, but only for a few years, analyses of expenditure incurred by joint boards, county boroughs, non-county boroughs, urban, and rural district councils on sewage disposal. Naturally enough, however, the plant employed and the treatment given are different in all places ; the population served, the volume of sewage and storm water treated, and the trade wastes and strength of sewage all vary, so that costs, even when averaged, must be used with caution. The Institute of Municipal Treasurers and Accountants issue annually a " Return of rates levied in the county and non-county boroughs and in urban and rural districts," but unfortunately there is only the one rate given for both sewerage and sewage disposal. It is a serious reproach to us that a country so densely populated that abstraction of potable water from, and discharge of sewage to, our rivers is of ever-growing importance in our national life, should lack basic information about the cost of purification of one of the main discharges to the rivers.

It is not universally known that the real difficulties of sewage purification are due to discharges of liquid wastes from trade premises. Most of these wastes can be purified satisfactorily when mixed with domestic sewage, but the proportions are sometimes of paramount importance. Indeed, many trade wastes, if discharged in too great concentrations, are inhibitory to biological purification, and it often happens that, in spite of all careful control at the sewage works and restrictive regulations at the factories, a discharge takes place which completely upsets the purification plant and in extreme cases renders it almost nugatory for days on end. No amount of knowledge of the best way to treat troublesome wastes avails against such varying conditions. The manager of the sewage works is helpless to control the quality of the raw sewage ; his purification plant will stand up to considerable variations in duty, but it has its limitations, and rapid adaptability from one duty to another is beyond man's control.

Carelessness, the human error, accident in the manufacturer's premises, or even on the public road, all threaten the efficiency of the work done by the sewage purification plant, and it cannot be too widely known that complete protection of our rivers from such acts of the public, whether accidental or illicit, is impossible.

In their final report of 1914 the Royal Commission on Sewage Disposal recommended that sewage effluent for discharge to an inland river where the dilution factor is at least eight, be purified to a defined standard which they called the " normal standard." That standard is more commonly recognised than any other and has been usually accepted in the past by river authorities as the reasonable limit of purification. Nevertheless, it sometimes results in pollution, a word of unequivocal meaning. The law, though permitting discharge of sewage, prohibits pollution, so that the sewage effluent must be at least as pure as the river water. In some circumstances this is impracticable and in some it is impossible.

Local authorities must, amongst many other duties, foster industry and drain the whole town. By so doing they make a rod for their own backs because too often the result is a sewage difficult to purify to the exacting standard required by law. Where a manufacturing town is situated on a small clean river the local authority may conceivably find itself under an order of the court to purify its sewage to an impracticable or even impossible degree.

Industrial wastes change as scientific discovery promotes new manufactures or dictates changes in old processes, so that the wastes discharged to the sewers alter in the course of time. Some of them are notoriously difficult to treat and all depend on the proportion of domestic sewage with which they are mixed. If the industrial wastes are in themselves a serious threat to our rivers as, for example, radioactive substances, or the domestic sewage is itself charged with modern detergents, the resultant purification problem may readily be beyond our present knowledge. Superimpose on this difficulty the smallness of our rivers, their increasingly heavy duty of conveying sewage effluents, and the increasing demand on them to supply water for public consumption, and the composite problem is seen to be one which cannot be resolved by harsh legislation.

It is known to-day that the sewage of our industrial towns can be purified far beyond the " normal standard " and it may safely be inferred that all sewage effluents could be similarly improved. The process is costly, but even so it does not always go far enough to satisfy the stringent demands of the law. Surely a country which led the world in public health engineering should not tolerate the possibility of a local authority suffering an order of the court which directs it to do something no one knows how to do ! New legislation is long overdue and is urgently required ; new standards of purification should have regard mainly to the value of the watercourse as a source of public water supply, and to a less degree to fishing and general amenity.

Lack of hydrological data of our hard-worked, small, but all the more precious rivers, is a reproach to us, and the public health engineer is not alone in his constant need of information which does not exist. Unless new standards of purification are to be postponed indefinitely they will have to be set up and applied without knowledge of one of the most fundamental factors affecting them.

DOUGLAS FIR PLYWOOD.—We have received several brochures outlining various uses of Canadian Douglas fir plywood, the import restrictions on which have recently been lifted. The booklets concentrate on the more recent Canadian applications—such as for panels of shuttering for concrete work—in the building industry. They are obtainable from the commercial secretary, Office of the High Commissioner for Canada Canada House, London, S.W.1.

Development of the Steam Turbine

By F. DOLLIN, B.Sc. (Eng.), M.I.Mech.E.*

In the 19th Parsons Memorial Lecture, presented before the Institution of Mechanical Engineers last Friday, October 29th, Mr. Dollin reviewed a number of the factors that continue to influence the development of the steam turbine. Here we reprint long extracts from the lecture which discuss blade and nozzle research equipment and results, effects of standardisation of steam conditions and turbine ratings and materials of construction.

Equipment Used for Blading Research

VERY early in his work on the steam turbine, Parsons, having introduced the principle of pressure compounding, satisfied himself that the best hydrodynamic efficiency was obtained with what is generally called "reaction" blading, but which, to be accurate, should be described as 50 per cent reaction. It was not Parsons's habit to disclose how he reached his conclusions, but it seems likely that in this instance he made experiments using water as the working fluid, and the correctness of his view as to the efficiency of 50 per cent reaction blading has never been seriously challenged.

In 1890, during the period when Parsons had temporarily lost control of his patents, he built an experimental turbine, which became known as "Jumbo," for radial-flow experiments. The following year saw the first use of separate blades and, as the art of manufacture developed, questions concerning shape and setting of blades demanded continuous attention and the need for a new and special experimental steam turbine became apparent.

Small Experimental Turbine.—A small experimental turbine was designed for seven stages of axial-flow 50 per cent reaction blading. The diameter of the drum was at first 4½in, later increased to 6in and then to 8in, which became the standard. The exhaust pressure was atmospheric, the absolute pressure at inlet 1·15 atmospheres, the normal power output about 5 b.h.p., and the steam flow 1600 lb per hour. This machine, which was named "Alice," was thus a very small unit, really a laboratory piece of equipment, and it proved invaluable in use. It was characterised by a very low Mach number, as was 90 per cent of the blading used in the turbines that Parsons was building, and by a low Reynolds number, although these criteria were not explicitly used in connection with turbine blading at that time. The small size of "Alice" enabled casings and rotors fitted with experimental blading to be produced comparatively quickly and economically, and the fact that it was a multi-stage turbine made it possible to include in the programme tests on clearance effects boundary forms and stage carry-over and carry-in. After a good many years' service "Alice" showed signs of considerable wear and tear, and a new turbine, designed for the same blading dimensions but with improvements in detail, was built to carry on the work. The new turbine, which was named "Alicia," has been illustrated in the *Proceedings* of the Institution (Dowson, 1938)†. Besides being suitable for multi-stage reaction blade tests, it is equally adaptable for test on a single-impulse stage of diameter 15in and it has been much used in both capacities. It is still on the active list.

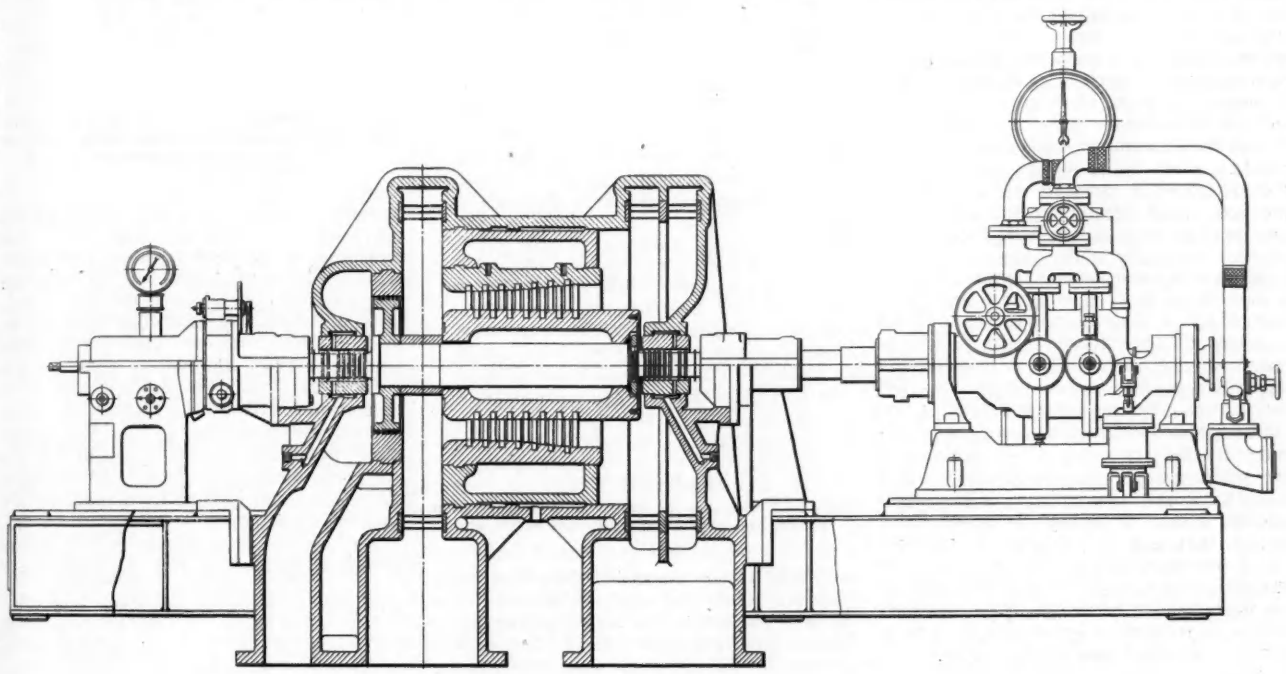


Fig. 1—New experimental turbine

Static Nozzle Tester.—Invaluable as "Alicia" was, the need was felt for some other means of testing that would greatly reduce the time and cost of producing units to be tested, and would be suitable for investigations with working conditions of bigger pressure ratios and higher Reynolds number than those of "Alicia." The work that the steam nozzles research committee of the Institution carried on for a number of years had attracted much attention, and it was decided that a static nozzle tester would be a useful machine in a capacity supplementary to "Alicia." The nozzle tester that was designed and built in 1934 was described in a paper published in the *Proceedings* of the Institution (Dollin, 1940)‡. It is quite different from that used by the steam nozzles research committee and more on the lines of one that was constructed in Germany by the A.E.G. (Faltin, 1926).§ The nozzles under test are suspended in such a way as to enable the reaction of the jet to be measured in both the axial and tangential directions, so that the mean efflux angle of the jets can be at once determined. The use of air instead of steam as the working fluid considerably simplified a number of problems, and the design and construction of the new tester benefited greatly from Parsons's interest in astronomical telescopes, inasmuch as the very sensitive, yet robust, suspension members were made in the neighbouring optical works of Sir Howard Grubb, Parsons & Co. on lines that had proved very successful in large wind tunnel balances for aircraft research work.

In the early tests the blade or nozzle packets were of arcuate form concentric with the axis of the tester, but now straight packets are used, as they enable tests to be carried out on the effect of incidence and, at the same time, are simpler to make. Experience has shown that over the range of nozzle height tested the replacement of arcuate by straight cascades does not appreciably affect the results obtained. One possibility that was in mind when the tester was designed was that a turbine wheel overhung from an absorption dynamometer could be placed in front of the nozzles and a study made of the conjoint action of nozzles and blades. I hope we will do this some day, and for such a test the nozzle packets would, of course, be in arcuate form.

Cascade Wind Tunnel.—The next addition

* Chief turbine designer, C. A. Parsons and Co., Ltd.

† Dowson, R.: 1938 *Proc. I. Mech.E.*, Vol. 138, page 267.

‡ Dollin, F.: 1940 *Proc. I.Mech.E.*, Vol. 144, page 147.

§ Faltin, H.: 1926 *Z.V.D.I.*, Vol. 70, 2, page 1582.

to the apparatus for investigating the performance of blading was a small high-speed cascade wind tunnel which was built at the Royal Aircraft Establishment and was installed primarily for the study of compressor blading, but has been used also for work on turbine blading.

The wind tunnel method of testing cascades is to measure the loss of energy of the fluid passing through the blades by traversing a total head tube before and after the cascade, the tube being combined with some form of yaw meter which serves the dual purpose of measuring the efflux angle and yawing the total head tube to the optimum direction. If the traversing is carried out carefully the total head tube (that is, Pitot tube) can undoubtedly give good results. Whether the total head tube is capable of recording accurately all the loss is perhaps a little doubtful, since, as Gibson‖ (1925) points out, it records V^2 and can therefore respond to fluctuations in the velocity which it may not be intended or desirable to record. It can, however, be extremely useful in defining the region of low loss and it is probably true to say that, had such a method of testing compressor blades been available to Parsons, his efforts to develop the axial-flow compressor would have been greatly furthered.

The new approach to the study of blading losses provided by wind tunnel methods of testing is accompanied by a different mental approach to fluid flow problems. Steam turbine designers from the earliest days have been accustomed to thinking in terms of flow through nozzles and blade passages, whereas modern aerodynamic thought considers the flow of fluid around aerofoils and other solid bodies. There is no doubt that the new outlook has given engineers a new awareness and has added greatly to our knowledge, and some aerodynamicists have been known to speak scornfully of the older outlook and have even suggested that it should be discarded altogether. Such an attitude, however, shows a lack of appreciation of the problems of the turbine designer, who is concerned not only with flow patterns, but also with mass flow and power output. The nozzle or blade passage area is something that can be specified and measured and that determines the flow capacity of the turbine. In one sense the problem of turbine blading design is simply the problem of fluid flow through orifices in series. It would seem, in fact, that, just as physicists use alternatively the wave theory of light and the quantum theory, so, in order to deal with all the flow problems involved, it is necessary sometimes to think of flow through a pipe or nozzle and sometimes of flow around an aerofoil.

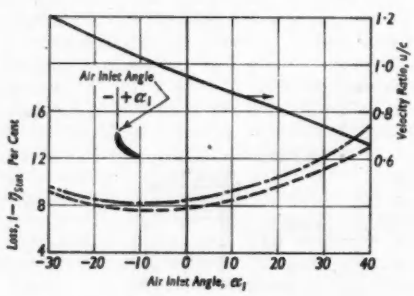
New Experimental Turbine.—Static methods of testing have proved of great value and are in constant use. At the same time they are no substitute for tests in a multi-stage turbine which constitutes the final court of appeal. The latest addition to the blading research equipment under review is a seven-stage reaction turbine (Fig. 1) somewhat on the lines of "Alicia" but larger. The spindle diameter is 13in and the normal speed of rotation 6000 r.p.m. The ratio of inlet/exhaust pressure is 1·6/1 and, when exhausting at atmospheric pressure, the steam flow is about 21,000 lb per hour and the power output 280 b.h.p.

One of the most important factors in connection with accurate turbine testing is the measurement of the inlet and outlet pressures. The inlet and outlet casings of the new turbine were developed by means of air tests with wooden models. The objectives were to ensure a reasonably uniform flow to the first stage and from the last stage and to establish positions of pressure measurement which would correctly represent the static pressure existing at inlet to the first stage and outlet from the last stage. The inlet and outlet annuli are similar in form, each having a circumferential perforated sheet baffle to assist in providing uniform conditions before and after the blading. The final arrangement is largely due to suggestions made by the late Mr. Stanley Cook, who delivered the third Parsons memorial lecture.

‖ Gibson, A. H.: 1925, "Hydraulics and Its Application," third edition, page 219 (Constable and Co., London).

Some Interesting Results Obtained in Researches on Blading

The various items of equipment that have been described are in many ways supplementary and complementary to each other, and results obtained with one tester can sometimes be checked by suitably devised tests in another. An example of corroborative evidence of this kind is furnished by the comparison of losses in normal reaction blading as determined in turbine and nozzle tests. The loss as determined on the nozzle tester with various air inlet angles ranging from minus 30 to plus 40 deg. is shown by the dotted line in Fig. 2, the ordinate scale being the loss expressed as a percentage of the available energy computed from the static pressure before and after the cascade. The broken line shows the corresponding curve derived from tests in the "Alicia" turbine over a range of velocity ratio equivalent to the same range of inlet angle, the relation between velocity ratio and inlet angle being shown by the upper curve. The agreement between the two loss curves must be considered remarkably good both as regards shape and position, although there is a gradually increasing divergence as the positive inlet angle increases. The slightly smaller minimum loss found in the nozzle tester is probably accounted for by the higher Reynolds number. The flatness of the curves over a wide range of inlet angle, say, from minus 30 to plus 15 deg., is characteristic of modern reaction blading.

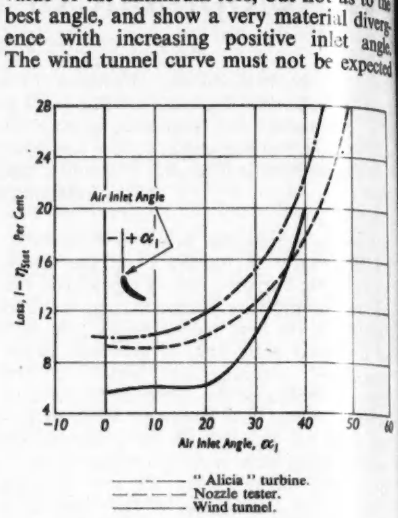


	Nozzle tester	"Alicia" turbine
Blade	640B	640B
Blade height, inch	0·875	0·875
Pressure ratio	1·10	1·01
O/P	0·37	0·35
P/c	0·592	0·598
R_e-chord $\times 10^{-4}$	17·6	4·3
R_e-H.M.D. $\times 10^{-4}$	1·63	0·38

H.M.D.—Hydraulic mean depth.

Fig. 2—Comparison of losses in normal reaction blading as determined in turbine and nozzle tests

It is not always found, however, that different experimental methods lead to concurrent results, and sometimes we are confronted with what H. G. Wells once called "the rich confusion of reality." Something of this kind is seen in Fig. 3, which shows the losses in semi-wing reaction blading as determined in tests made with the "Alicia" turbine, the nozzle tester, and the small wind tunnel. In this case the curves for "Alicia" and the nozzle tester are corroborative as to the value of the minimum loss, but not as to the best angle, and show a very material divergence with increasing positive inlet angle. The wind tunnel curve must not be expected



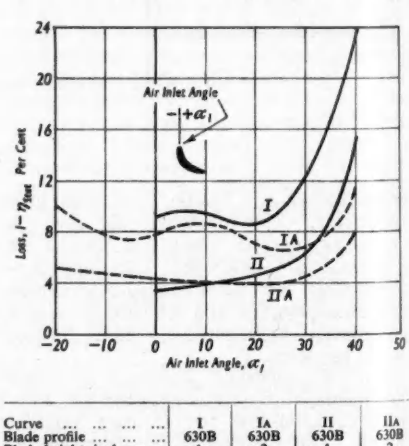
	Nozzle tester	High-speed cascade tunnel	"Alicia" turbine
Blade profile	640B	630B	630B
Blade height, inch	0·875	1·0	0·875
Pressure ratio	1·10	1·10	1·01
O/P	0·499	0·50	0·484
P/c	0·65	0·66	0·62
R_e-chord $\times 10^{-4}$	20·1	11·3	2·95
R_e-H.M.D. $\times 10^{-4}$	2·58	1·57	0·38

H.M.D.—Hydraulic mean depth.

Fig. 3—Comparison of losses in semi-wing reaction blading as determined in turbine, nozzle tester, and wind tunnel experiments

to agree with the others, as it represents, not the total loss, but only the profile loss measured at the mid-height of the blade. What is remarkable about it is the very steep rise when the positive angle exceeds 30 deg., the profile loss then exceeding the total loss as determined from the nozzle tester results. This apparently anomalous result cannot easily be explained, but is not necessarily to be rejected as erroneous, as somewhat similar results have been found by other investigators in wind tunnel tests on short blades. For three-dimensional tests on short blades the nozzle tester is considered more reliable than the wind tunnel.

The very searching nature of wind tunnel tests is illustrated in Fig. 4, which again



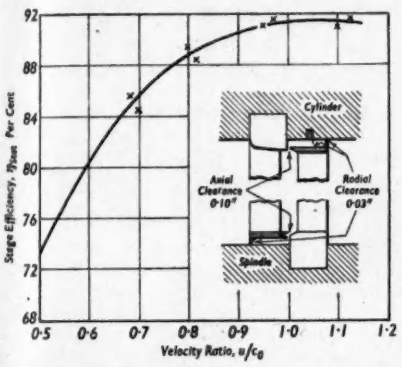
Curve	I	IA	II	IIA
Blade profile	630B	630B	630B	630B
Blade height, inches	1	2	1	2
Tunnel	Small	Large	Small	Large
R_e-chord $\times 10^{-4}$	5·83	6·14	19·06	19·47
R_e-H.M.D. $\times 10^{-4}$	0·82	0·93	2·68	2·95
Mach number	0·2	0·2	0·6	0·6

H.M.D.—Hydraulic mean depth.

Fig. 4—Wind tunnel tests on semi-wing reaction blading

shows the losses for semi-wing blading in dependence on air inlet angle. Curve 1 shows the results obtained with a cascade of blades 1in high in the small wind tunnel at a Mach number at outlet of 0·2. The hump occurring between zero angle and plus 20 deg. looked peculiar and improbable. This impression was strengthened when the tests were repeated at a Mach number of 0·6, for not only were the losses found to be much smaller (as expected) but there was no trace of a hump. A precisely similar cascade, except that the blade length was increased from 1in to 2in, was then made and tested at the same values of Mach number in a larger wind tunnel at another research establishment. The results of these tests are shown by the dotted lines and it is seen that they reproduce in a remarkable way the characteristics of the tests in the small tunnel. The fact that the losses are in general, a little smaller is probably attributable to the bigger aspect ratio. The hump that occurs at the low Mach number (that is, low Reynolds number) is probably due to the flow in the boundary layer tending to become laminar.

As an example of the kind of information that can be obtained only from a multi-stage turbine, Fig. 5 shows the results of some



Stage efficiency with clearance loss plotted against velocity ratio. Blade profile, 660B ; mean blade height, 2·8in ; axial clearance, 0·10 ; radial clearance, 0·03 ; R_e-chord $\times 10^{-4}$, 13·7 ; R_e-H.M.D. $\times 10^{-4}$, 1·44.

Fig. 5—Tests on normal-reaction blading in large experimental turbine

tests made on normal-reaction blading in the large experimental turbine. The ordinate scale is the stage efficiency with clearance losses as run and the base scale is the adiabatic velocity ratio. The blading used is similar in all essentials to that employed commercially in current designs of high-pressure turbine. The fixed and moving blades carry shrouds which provide one axial and one radial seal in each case and a second radial seal at the outer surface of the spindle blade shrouding is provided by a strip caulked into the cylinder. For the tests under consideration the axial clearances were 0·10in and the radials 0·03in, the mean blade height being 2·8in. With these clearances the peak efficiency obtained was just under 92 per cent. The fact that this form of blading is not dependent on the maintenance of very fine clearances for high efficiency gives the designer considerable freedom in the matter of turbine layout and arrangement.

The tests just described, when corrected to zero clearance, represent a blading efficiency approaching 95 per cent. This is in association with a not very high Reynolds number and an aspect ratio of about 2½/1, and it is evident that further improvements in blading efficiency must be expected to be small in magnitude and hard to achieve. In this connection a few words may be said about what is commonly called vortex blading, for which claims of greatly improved efficiency as compared with straight blading have at times been made in connection with gas turbines.

The term "vortex" is rather loosely applied to any one of several possible combinations of tangential and axial-flow conditions, the factor common to them all being the recognition of a radial pressure gradient in the annular space between the fixed and moving rows in each stage of any axial-flow turbine. The equation for the radial pressure gradient is

$$\frac{dp}{dr}=\frac{\rho}{g}\left[\frac{C_t^2}{r}-\frac{dC_r}{dt}\right]$$

where C_t and C_r are the tangential and radial components of fluid velocity at radius r. If it be assumed that "cylindrical" flow exists, dC_r/dt is zero, and an explicit mathematical solution is then possible. In this context the more commonly used combinations of tangential and axial flow are shown in Table I.

The condition of constant work done at all radial distances from the centre corresponds

TABLE I—*More Commonly Used Combinations of Tangential and Axial Flow*

Axial flow	Tangential flow	
	Constant work done	Radial stability
Constant velocity	Case 1	Case 1
Constant mass velocity ...	Case 2	Case 3
Constant nozzle angle ...	Case 4	Case 5

to the aerodynamic ideal of constant circulation round the blade. Radial stability denotes equilibrium between the centrifugal force field and the radial pressure gradient in the steam flow, and is considered in reference to the annular space between the fixed and moving blades.

The term "free vortex" describes the combination of constant work done with constant axial velocity. This automatically fulfils the condition of radial stability, but with a compressible working fluid involves some radial movement of the fluid outward in the stator blade row and inward in the rotor blade row. This latter condition is obviated if constant axial velocity is replaced by constant mass velocity, and this may be combined either with constant work done or with radial stability, but not with both unless the working fluid is incompressible.

Whichever type of vortex design is employed, twisted blades of varying profile are required, especially for the rotor. Such blades approximate more closely to ideal incidence conditions all along the blade than do straight blades of constant section and for this reason, if for no other, might be expected to show a higher efficiency in stages where the ratio of tip diameter/root diameter is relatively big.

The late Dr. Robert Dowson, who was in charge of blading research at our works for many years, gave a great deal of study to vortex theory and several sets of blades were made and tested in the "Alicia" turbine with a view to comparing the efficiency obtained with straight blades, blades twisted and flattened in accordance with the free vortex theory and also blades having a smaller degree of twist to give constant opening coefficient at all radii. For these tests the blades were made much longer than normal for "Alicia," the ratio tip diameter/root diameter being 2/1. These tests showed that the efficiencies of the several sets of blades were indistinguishable. This negative result does not stand alone, and it is to be inferred that fresh experimental evidence would be needed to justify the adoption of vortex blading generally, instead of only in the low-pressure stages where it is at present employed.

Standardisation of Steam Conditions and Turbine Ratings in Great Britain

Turning now from hydrodynamics to thermodynamics, a salient factor in the period under review has been the standardisation of steam conditions and turbine ratings. The time and labour that manufacturers have at times had to spend in working out designs and building plant to conform with an almost infinite variety of specified steam conditions and turbine ratings was a great handicap on production, and represented an enormous economic loss. This was fully realised before the 1939–45 war by manufacturers, consultants, and many purchasers in all parts of the world and the desire for some measure of uniformity became widespread. In Great Britain, when the electricity supply industry was nationalised after the war, the time was ripe and conditions were favourable for the adoption of standard steam conditions, together with standard turbine ratings.

At the time of Sir Charles Parsons's death in 1931 the steam turbine had already reached a considerably advanced stage of development. It was about this time that steam conditions of 600 lb per square inch pressure and 800 deg. to 850 deg. Fah. temperature were adopted for several new power stations for which a number of 30MW sets running at a speed of 3000 r.p.m. were built. Machines of this rating to operate with these steam conditions were one of the two standards first specified by the newly created British Electricity Authority in 1947, and it seems appropriate therefore to take them as a datum for comparison.

A second standard laid down at the same time by the B.E.A. was for 60MW maximum and economical rated machines for steam conditions of 900 lb per square inch, 900 deg. Fah. The concentration of these two standards was a wise policy and helped to make possible a big increase in the production of turbine generators which were urgently needed as the first step towards relieving the acute shortage of such plant at the time.

Having launched a big programme of these standard units the B.E.A. next placed orders for machines to operate with higher steam conditions, including 100MW units with steam conditions of 1500 lb per square inch, 1050 deg. Fah., others of the same rating for conditions of 1500 lb per square inch, 975 deg. Fah., with reheating to 950 deg. Fah., and 120MW units for conditions of 1500 lb per square inch, 1000 deg. Fah., reheating to 1000 deg. Fah. Hard on the heels of these there are now in the advanced design stage 200MW units for steam conditions of 2350 lb per square inch, 1050 deg. Fah., reheating to 1000 deg. Fah.

When the first standards were laid down by the B.E.A. there was no stipulation as to vacuum, which did in fact vary considerably between different stations according to the cooling water available, 29·0in of mercury being a normal vacuum for stations with river water cooling and 28·5in of mercury for stations dependent on cooling towers. However, as more and more stations go into commission there is a gradual increase in the average river water temperature, while, on the other hand, the efficiency of cooling towers has been materially improved and, in consequence, the difference in vacuum as between river stations and cooling tower stations has narrowed. Average values to-day would be about 28·9in for river stations and 28·7in for cooling tower stations.

Effect of Steam Conditions on Efficiency and Output

The question of the improvement in efficiency with higher steam conditions is one of primary importance, and has been the subject of several published papers and articles in the technical Press. It is not proposed to deal with it at length here, but it is appropriate to look at the results obtained or expected from the various B.E.A. units already mentioned. The relevant figures are set out in Table II.

It will be seen that the thermal efficiency of the 30MW turbine generator, excluding all auxiliaries, is as high a 34·8 per cent. Each successive column shows an increase, the figure for the 200MW unit being 44·2 per cent.

The necessary allowances for the auxiliary power and steam requirements depend on a great many factors and are liable to some variation, but the figures given in Table II are reasonable estimates on a comparable footing for the various units. As between a reheat and non-reheat machine for the same initial pressure and temperature, there is an appreciable reduction in auxiliary power for the reheat machine on account of the considerably lower steam consumption which is reflected in the boiler feed pump power.

Table II—*Thermal Efficiency and Other Data for Turbines Operating on Various Steam Cycles*

	1	2	3	4	5	6
Stop valve pressure, pounds per square inch gauge ...	600	600	900	1500	1500	2350
Stop valve temperature, degrees Fahrenheit	850	850	900	1050	1000	1050
Reheat temperature, degrees Fahrenheit...	—	850	—	—	1000	1000
Feed water temperature, degrees Fahrenheit	330	355	385	450	435	472
Stages of feed heating	4	4	5	6	6	6
Economical rating, MW	24	50	60	100	120	200
Maximum rating, MW...	30	50	60	100	120	200
Thermal efficiency, excluding auxiliaries, per cent	34·8	36·7	37·4	40·4	41·6	44·2
Deduction for turbine auxiliaries,* per cent	2·1	1·85	2·4	2·75	2·5	2·9
Corrected thermal efficiency, per cent	34·07	36·02	36·5	39·3	40·56	42·9
Relative fuel consumption	100	94·5	93·3	86·7	84·0	79·3
Steam rate to turbine, pounds per kilowatt-hour	8·4	7·51	8·36	7·59	6·69	6·35
Steam rate to condenser, pounds per kilowatt-hour ...	6·72	5·80	6·12	5·31	4·76	4·32
Relative output for constant last row annulus and constant per cent leaving loss	100	114	112	135	151	170

All figures based on 28·9in vacuum at turbine exhaust.
* Including boiler feed pump.

Comparing column 2 with column 1, it is seen that with the same initial conditions of 600 lb per square inch, 850 deg. Fah., intermediate resuperheating to 850 deg. Fah. shows a saving in fuel consumption of 5·5 per cent. Some proportion of this gain is due to the bigger rating of the reheat machine, the net gain directly attributable to reheating being about 5 per cent.

Comparing columns 3 and 1, it is seen that for the 60MW units operating with steam conditions of 900 lb per square inch, 900 deg. Fah., there is a fuel saving of 6·7 per cent as compared with the 30MW units. About 1 per cent of this is due to the higher efficiency of the generator, the 60MW unit being hydrogen cooled and the 30MW air cooled.

It will perhaps cause some surprise on looking at column 4 to see that the step from 900 lb per square inch, 900 deg. Fah., to 1500 lb per square inch, 1050 deg. Fah., achieves no greater saving in fuel consumption than the step from 600 lb per square inch, 850 deg. Fah., to 900 lb per square inch, 900 deg. Fah. This is an illustration of the increasing difficulty attendant upon each successive advance.

For the 120MW unit the saving in fuel consumption as compared with the 30MW unit is 16 per cent, and for the 200MW unit the corresponding saving exceeds 20 per cent. The effects of increased pressure and temperature on the maximum output obtainable are perhaps more striking than their effects on thermal efficiency. With higher steam conditions, the energy available by adiabatic expansion is increased and the steam rate to the turbine correspondingly reduced. At the same time, a greater proportion of the steam is bled to produce a higher feed water temperature and, in consequence, the steam rate to the condenser is further reduced. Therefore, for a given last row blade annulus area and steam exit velocity, the power output increases markedly with increase of initial pressure and temperature. Furthermore, in view of the increased available energy with the high conditions, a given steam-exit velocity represents a smaller percentage leaving loss, and for equal percentage leaving loss the output obtained with increased steam conditions is still further enhanced. The relative figures computed on this basis are shown in Table II, the output for the 600 lb per square inch, 850 deg. Fah. steam conditions being taken as 100.

On comparing column 2 with column 1, it is seen that the adoption of reheating, while retaining the same initial pressure and temperature, enables 14 per cent more power to be obtained with a given exhaust area for the same percentage leaving loss. A very similar result is found from comparison of columns 5 and 4, bearing in mind that in this case the comparison is a little affected by a difference in the stop-valve temperature. These comparisons bring out the important effect of reheating on the output factor, and it is evident that when units of the maximum possible output are required, reheating must always be employed. It will be seen that with steam conditions of 2350 lb per square inch, 1050 deg. Fah., reheating to 1000 deg. Fah., the relative output as compared with 600 lb, 850 deg. Fah., is 70 per cent greater.

In connection with the question of the effect of steam pressure and temperature on the cycle efficiency it may be remarked that technical development has again run ahead of scientific knowledge relating to the properties of steam. A temperature of 1050 deg. Fah. is already accepted for large steam turbines and still higher temperatures are in prospect. The Callendar steam tables at present in use do not extend beyond 1000 deg. Fah. The Keenan and Keyes tables extend to 1600 deg. Fah., but are based on extrapolation of experimental data at temperatures not exceeding 860 deg. Fah. and do not coincide with the Callendar data at the upper end of the chart. Some new steam tables have recently been issued in Russia based, it is understood, on experiments at temperatures up to 1112 deg. Fah., but not in conjunction with very high pressures.

In comparing cycle efficiencies, using different steam tables, it is possible to obtain results differing by several tenths of 1 per cent. The importance of this may be appreciated when it is realised that the capitalised value of one-tenth of 1 per cent on the consumption of a 120MW unit is over £5000. The British electrical industry has for long been very much alive to this and, in 1946, allocated funds in support of new researches on the thermodynamical properties of steam in the field of high pressure and temperature. Apparatus for the very exact measurement of the total heat of steam at pressures up to 6000 lb per square inch and temperatures up to 1400 deg. Fah. has been designed and built and calibrated at the Imperial College of Science and Technology under the direction of Professor D. M. Newitt, F.R.S. The obtaining and formulating of data that will enable a new steam table and chart to be issued, extending up to at least 1200 deg. Fah., as a first stage, is a matter of urgent importance.

A new factor in the power situation is the advent of the atomic pile, which turns attention in a different direction from the trend towards higher pressures and temperatures that we have been reviewing. Sir Christopher Hinton (Hinton, 1954)¶ has stated that although there is no nuclear-physical reason why the fission process should not be operated at a very high temperature there are compelling engineering and metallurgical reasons for not attempting to do so at the present time. For the gas-cooled natural uranium reactor he gives 350 deg. Cent. (662 deg. Fah.) as the approximate temperature of coolant leaving the reactor, which limits the temperature of the working fluid for the prime mover to about 600 deg. Fah. The design problems associated with steam turbines for atomic power plant are therefore at the opposite end of the scale from those associated with modern coal-fired plant, and arise from the relatively small available energy, the big volumetric flow in relation to the power output and the use of steam with a higher moisture content than normal. Atomic power plant is at present only in the embryonic stage and its potentialities offer a fascinating and unpredictable field of development.

Materials of Construction

When dealing with ferrous metals at temperatures not exceeding, say, 800 deg. Fah., their mechanical properties need be considered only in terms of the relation between stress on the one hand and deformation and fracture on the other. In the high-temperature region, however, the effect of an applied stress depends on the temperature and also on the time for which it is applied, and the mechanical properties of the metal therefore have to be considered in terms of the relations between stress, temperature and time on the one hand and deformation and fracture on the other.

Steam turbine rotors and casings and other main parts normally work under conditions of approximately constant stress. A criterion that is commonly used in the design of such components for high-temperature steam turbines is that under the working stress/temperature conditions the material should not extend by more than 0·1 per cent in 100,000 hours, a period equivalent to eleven years' continuous operation. It is also necessary that the working stress should be well below the stress-to-rupture in the same period. Sometimes a factor of safety of 2 on the rupture stress is employed, and this not infrequently gives a working stress about

¶ Hinton, C.: 1954 *Proc. I.Mech.E.*, Vol. 168, page 55, "Nuclear Reactors and Power Production."

equal to, or rather less than, that corresponding to 0·1 per cent creep in 100,000 hours. These criteria together are considered to provide a safe and conservative basis for design, and may not always give the highest permissible stress.

Plain carbon steel has been employed successfully for forged rotors, and cast cylinders and steam chests with operating temperatures up to 800 deg. Fah. For the same components in turbines operating with steam at 850 deg. Fah. carbon steel with the addition of 0·5 per cent molybdenum can be regarded as standard, and this material has proved satisfactory for turbine rotors and casings with operating steam temperatures up to 925 deg. Fah.

It has also been in extensive use for a number of years for steam pipes, but the bursting of a steam pipe in the United States in 1943 drew attention to the fact that the heat-affected zones adjacent to welds are liable to develop serious weakness as a result of graphitisation during prolonged exposure to temperatures extending upwards from 850 deg. Fah.

The addition of 1 per cent chromium to carbon-molybdenum steel greatly increases the resistance to graphitisation and also improves the creep properties to some extent. This steel has therefore superseded carbon-molybdenum steel for pipes.

The resistance to creep of carbon-molybdenum and chromium-molybdenum steels falls off rapidly as the temperature approaches 1000 deg. Fah., and for this field we turn to the group of ferritic steels containing molybdenum and vanadium, the high-temperature mechanical properties of which depend on the

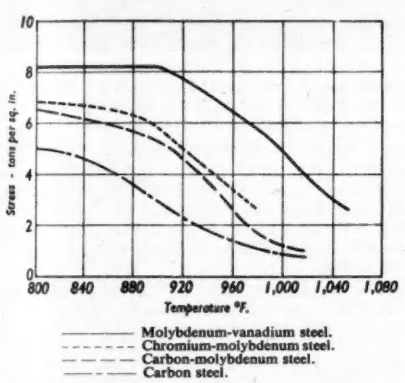


Fig. 6—Stress-temperature relation for 0·1 per cent creep in 100,000 hours

heat-treatment they have received. The original molybdenum-vanadium steel contained 0·5 per cent molybdenum and 0·3 per cent vanadium with a carbon content of 0·12 per cent and no chromium. From this a number of chromium-molybdenum-vanadium steels have been developed containing various combinations of chromium up to 3 per cent, molybdenum up to 1 per cent, and vanadium up to 0·8 per cent.

Fig. 6 shows the stress-temperature relation for 0·1 per cent creep in 100,000 hours plotted against temperature for carbon, carbon-molybdenum, chromium-molybdenum, and molybdenum-vanadium steels. Subject to possible modification as experience grows, it seems probable that molybdenum-vanadium or chromium-molybdenum-vanadium steels should have adequate strength for the main components of steam turbines working at temperatures up to 1050 deg. Fah.

Bolt steels are required to have a high yield point at room temperature as well as good creep properties, and for this reason they sometimes have a high carbon content and are used in the quenched and tempered condition. For many years the normal bolt material was a chromium-molybdenum steel containing 0·6 per cent molybdenum, 1·4 per cent chromium, and 0·4 per cent carbon and this has proved satisfactory in service on turbines operating at temperatures up to 925 deg. Fah., the bolts themselves being some 50–100 deg. Fah. lower in temperature. Chromium-molybdenum-vanadium bolt steels have now been introduced, the best of which seem to be some 100–150 deg. Fah. better than chromium-molybdenum steel for the same creep rate at a given stress.

Bolts are generally subjected in service, not to constant stress, but to constant total strain. In the course of time, as the material creeps, the elastic strain (and therefore the stress in the bolt) diminishes. This is not disastrous, but sooner or later the tension in the bolts diminishes so far that re-tightening of the bolts becomes essential to prevent leakage at the joint.

For blading, 13 per cent chromium stainless iron or steel has for long been the standard material of nearly all turbine manufacturers. Its creep resistance is about the same as that of plain carbon steel, but as the direct stress in the blades at the high-pressure end of a turbine is not usually very high, stainless iron has proved quite satisfactory in steam turbines at 925 deg. Fah. For higher temperatures, blading material with better creep properties is needed to ease the problems of design, and a stainless iron containing 0·8 per cent molybdenum has been introduced. This has a creep resistance similar to carbon-molybdenum steel and can probably be used up to about 1000 deg. Fah. Much work is being done on the development of more complex steels in this group, and there is every prospect that the field of application of stainless ferritic steels will be considerably extended.

The temperatures employed with modern steam turbines have now risen to a point where it is necessary that the materials should have not only suitable mechanical properties, but also satisfactory oxidation resistance under the working conditions. The high-temperature mechanical properties of carbon-molybdenum and chromium-molybdenum steels restrict their use to temperatures at which their resistance to oxidation is fully adequate. The molybdenum-vanadium and chromium-molybdenum-vanadium steels have much better high-temperature mechanical properties, but no better resistance to oxidation, and it is important to know whether the upper limit of temperature for which these steels are suitable is determined by creep properties or oxidation resistance. From the point of view of oxidation resistance it can be said that all these low-alloy steels become unsuitable for use at temperatures above about 1050 deg. Fah.

When steels are required to withstand stress and oxidation for long times at temperatures above 1050 deg. Fah. it is generally considered necessary at the present time to use austenitic steel of the 18 per cent chromium, 12 per cent nickel, and 1 per cent niobium type. There are, however, serious objections to the use of austenitic steels. They are expensive, difficult to cast and forge, and not easy to machine. They have a low yield point at room temperature, a high coefficient of expansion which gives rise to big movements or forces and makes the control of clearances difficult, and a low thermal conductivity which, in conjunction with the high coefficient of expansion, gives rise to high thermal stresses. Because of these difficulties much attention is now being given to the development of 6 per cent and 12 per cent chromium ferritic steels alloyed with such elements as titanium, vanadium and niobium to give high creep resistance. It is hoped that in this way the temperature at which it becomes necessary to use austenitic steels can be raised to 1150 deg. Fah.

A topic that has received considerable attention in recent years is the thermal instability of rotors. Assuming that the forging is received by the turbine builder from the steel works in the normalised condition, it should be free from internal stresses, and there are then two kinds of instability that may occur, the characteristic features of which are illustrated in Fig. 7. In the first case, when the shaft is heated while rotating slowly it starts to bow and shows an increasing deflection with increase of temperature up to a certain point, beyond which the deflection diminishes until the shaft is nearly straight. It remains in this condition while cooling down and shows no repetition of the initial high deflection when heated up a second time. This " once only " deflection is presumably due to some surface effect resulting from the machining of the shaft, and it can be taken care of by slowly rotating and heating the shaft before it is bladed.

In the second case the shaft develops a bend increasing in proportion as the temperature is raised, straightening out during cooling down and showing precisely the same bend when heated a second time. This kind of shaft is not usable and cannot be cured by anything the turbine builder can do. At our works this phenomenon has not been encountered with carbon steel shafts, but it has occurred occasionally with carbon-molybdenum steel shafts and has been very

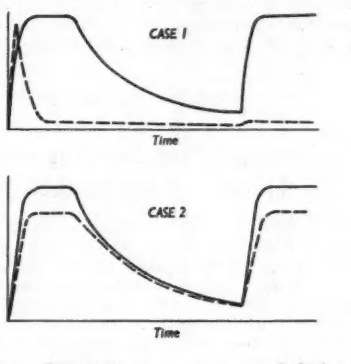


Fig. 7—Thermal instability of rotors

fully investigated in conjunction with the steel makers. It has now been established that the difficulty arises from non-uniformity of structure in the forging. Coefficient of expansion determinations carried out on specimens cut from each side of the shaft showed the coefficient on the convex side to be slightly greater than on the concave. Although the difference is only 1 or 2 per cent it is sufficient to produce a shaft deflection at steam temperature of the order of 0·01in, which is more than sufficient to throw the shaft so far out of balance that it cannot be run.

A detailed account of the investigation of the thermal instability of turbine shafts by A. Barker and F. W. Jones, of the Brown-Firth Research Laboratories, will shortly be published. Their work has shown that the difference in coefficient of expansion between one side of a shaft and the other arises from the development during normalising of a bainitic structure on one side of the shaft and a pearlitic structure on the other. This structural difference arises in turn from some

difference in the heating temperature or rate of cooling between one side of the shaft and the other. The composition of the steel used has an important influence in this connection. Thus with carbon steel shafts it is possible to have substantial differences in the heating temperature or rate of cooling on opposite sides of a shaft and still get a pearlitic structure all round and, again, with shafts containing a sufficient amount of alloying elements it is possible under similar conditions to get a bainitic structure all round. It is in shafts made of carbon-molybdenum and molybdenum-vanadium steels that slightly unsymmetrical heating or cooling is liable to produce a bainitic structure on one side and a pearlitic on the other and thus give rise to a difference in expansion. It is a wise precaution to test all shafts of these materials for thermal stability before they are bladed.

The intermediate-pressure turbine shaft of a large reheat machine presents a particularly difficult problem, as it is large in size and needs to possess in combination a high resistance to creep at the hot end, a high yield point at the cool end, and freedom from thermal instability. The choice of materials for such applications is restricted by reason of the fact that only a few steels are known to have sufficiently good creep properties and their compositions are not the most suitable for giving a high yield point and ensuring thermal stability in large shafts. In these circumstances a satisfactory solution of the problems involved may be assisted by resorting to oil hardening instead of normalising, since this makes it easier to obtain a high yield point in the body of the material at the cold end and also increases the creep resistance at the hot end. As a safeguard against thermal instability, vertical heat-treatment associated with rotation is important.

Miniature and Sub-Miniature Precision Potentiometers

We learn that two new precision potentiometers have been added to the range recently introduced by Salford Electrical Instruments, Ltd. They are linear miniature and sub-miniature potentiometers and have been developed for use in applications where space is very limited—for example, in some computing devices, time base generators and electronic control systems.

The miniature potentiometer, designated "D.2," weighs only 15g and is 1¼in in diameter; it covers a resistance range from 1000 to 90,000 ohms and has a power rating of 1W. The maximum resolution obtained is six turns/degree and the standard electrical angle is 340 deg. There are two taps on the standard model, each being made to a single turn of wire. A keyed locating spigot fitted to the housing allows up to three units to be ganged on a single shaft. The torque with plain bearings is approximately 5g-cm, but ball bearings can be fitted if necessary and the torque is then of the order of 2–3g-cm.

The sub-miniature potentiometer, known as the "S.D.," embodies a special resistance card and clamp ring assembly. The complete potentiometer weighs only 4g and measures ⅜in in diameter by ½in in length, the length being taken from the front of the case to the rear of the housing, excluding terminal or spindle projection.

The resistance range covered by this instrument is from 200 to 8000 ohms. The maximum resolution is two turns/degree and the power rating ½W. There are two taps and the electrical angle is 280 deg. The sub-miniature potentiometer cannot be ganged, and is essentially a "trimmer" and unsuitable for servo application. It can, however, be supplied with a ¼in long shaft or with a screw adjustment as required.

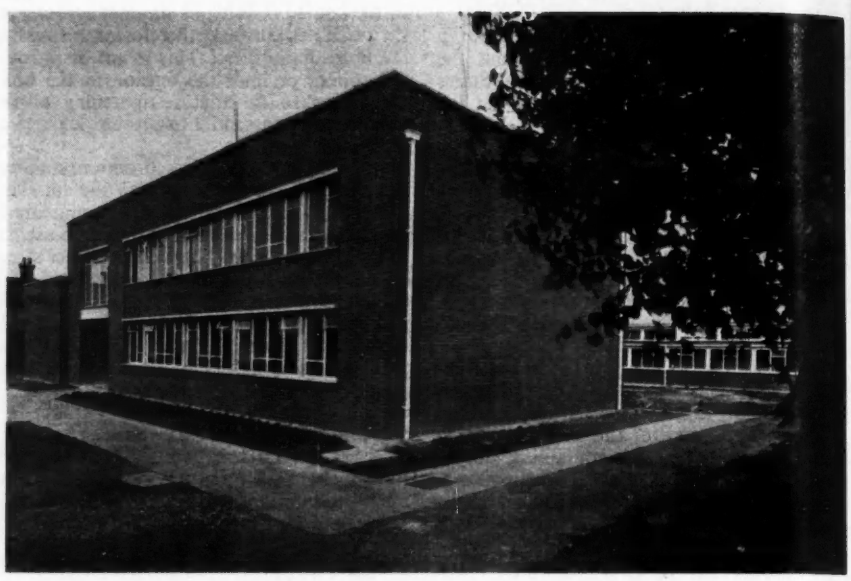
Marconi College

Last week we visited the new building which houses the laboratories, lecture rooms and administrative wing of Marconi College, Chelmsford, Essex. The college is part of the organisation of Marconi's Wireless Telegraph Company, Ltd., and, since its foundation in 1901, it has been concerned with the training of the company's apprentices and employees and of engineers from overseas.

Advanced post-graduate training is provided in radio, radar and electronics. Most of the British students of the college are drawn from the employees or apprentices of Marconi's Wireless Telegraph Company, Ltd., or of the other companies in the English Electric group. The majority of them are either graduate apprentices or student apprentices, and in either case the work at Marconi College forms part of their overall training programme. Of the graduate apprentices about two-thirds have an engineering degree (with a bias towards communications engineering) and the remainder have degrees in science (usually physics) or in mathematics. Usually the student apprentices have a Higher National Certificate in engineering. Another group of students is made up of new technical employees of the company, who attend the College for a few months before starting work in the laboratories. The few British students outside the company include members of the armed forces.

About half of the total number of students at the College come from overseas. They vary widely in their qualifications, but, in many cases, they are graduates in science or engineering. Most of them are nominated by their governments or by the company's customers or agents overseas, but a few students are accepted as private individuals.

The function of the College is to meet the needs of these two main groups of students. In no sense does the College assume the functions of



Administrative wing of Marconi College for advanced training in radio and electronics. One of the two wings containing laboratories and lecture rooms can be seen in the background, right

Typical laboratory in the new Marconi College building. Two groups of overseas students are seen studying the operation and maintenance of the "AD200" direction finding equipment

a university or technical college. The majority of the company's employees are trained for posts in the research and design (development) laboratories and the remainder for the installation and other divisions of the company. Many of the overseas students require a similar training. Others, who will be responsible for maintaining and, in some cases, installing Marconi equipments require shorter courses on specific equipments, and a number of such courses are available. Most of the students, however, take a five-month engineering course in either radio, radar or television. A preliminary ten-week course is provided for the benefit of students, for example, mathematics students, who may need to become familiar with the fundamentals of electronics before joining a five months' engineering course.

Throughout the College the emphasis is on practical training : the main instructional effort is concentrated on laboratory work rather than academic studies and only about a quarter of each course is taken up by formal lectures. The laboratory curriculum is designed to develop a sense of detailed appreciation of the behaviour of electronic circuits, an ability to carry out accurate measurements and to assess the relative importance of the numerous factors involved in designing any equipment. Students of similar technical standards are placed in groups, two or three strong, for laboratory work, and at the start of each experiment they receive brief written instructions outlining the work to be done. To ensure that the students may develop initiative, these instruction sheets provide only a brief outline of the procedure and the main decisions must be made by the members of the team.

New Marconi College Building

Since the war there has been a rapid increase in the demands made upon the training facilities offered by the Marconi College. No less than 260 students from thirty-three overseas countries have completed the full five months' engineering courses. They include seventy-nine from India, forty from Norway, twenty-eight from Pakistan, sixteen from Sweden, twelve from Egypt, ten from South Africa, and ten from the Argentine. The new building is designed for nearly 100 students and residential accommodation for nearly fifty students is being provided in a separate house.

The new building consists of an E-shaped block, which is single storied, except for the administrative wing, as illustrated opposite. The main limb of the building consists of lecture rooms, store rooms and workshops ; two of the three wings house most of the laboratory rooms and the third wing, seen in our illustration, accommodates the administration and conference rooms. In all there are two lecture rooms, ten laboratory rooms, a technical library and a workshop.

During our short tour of the laboratories we saw typical courses of students at laboratory work. In one of the radar laboratory rooms we saw groups of students working on servo mechanisms ; one team was examining the characteristics of a " Magslip " position control servo system, another team was making a practical study of a magnetic amplifier controlling a motor-generator servo loop. In another room one group was investigating multivibrators and another was working on Miller time-base circuits and " flip-flops." In a room devoted to operational radar equipment we saw Mark III and Mark IV " Radiolocator " sets. Students were investigating the characteristics of these sets, making adjustments on the Mark III equipment and using the Mark IV as a standard of comparison.

On the radio engineering course a group of students was engaged in the design and construction of a superheterodyne receiver. In another room containing power amplifier and transmitter equipment a team was engaged in experimental matching of the output stage of a v.h.f. transmitter loaded by an outdoor transmission line erected on land adjoining the laboratory room.

One of the laboratory rooms used for the television engineering courses is equipped with studio equipment as used by the B.B.C., including a typical camera chain and control unit with monitors and facilities for vision mixing and channel switching. To demonstrate the industrial uses of television there is a " Vidicon " camera tube mounted on an optical microscope, with a display such as might be used for educational purposes.

A typical laboratory is depicted in our second illustration on page 628, which shows direction-finding equipment being used by two teams of overseas students for instruction on operation and maintenance.

An important auxiliary service to the instruction offered by the College is provided in a drawing-office school which occupies a separate single-storey building. The old Marconi College building is now being converted to form an annexe to the existing hostel, where each student has a centrally-heated private study-bedroom provided with hot and cold running water. On the ground floor there are comfortably furnished lounges, recreational rooms, and a dining room.

The principal of Marconi College is Mr. R. E. Burnett, M.A. (Oxon), A.M.I.E.E., A.Inst.P., and the director of studies is Mr. R. G. Hulse, B.Sc.

Continuous Supply Automatic Power Plant

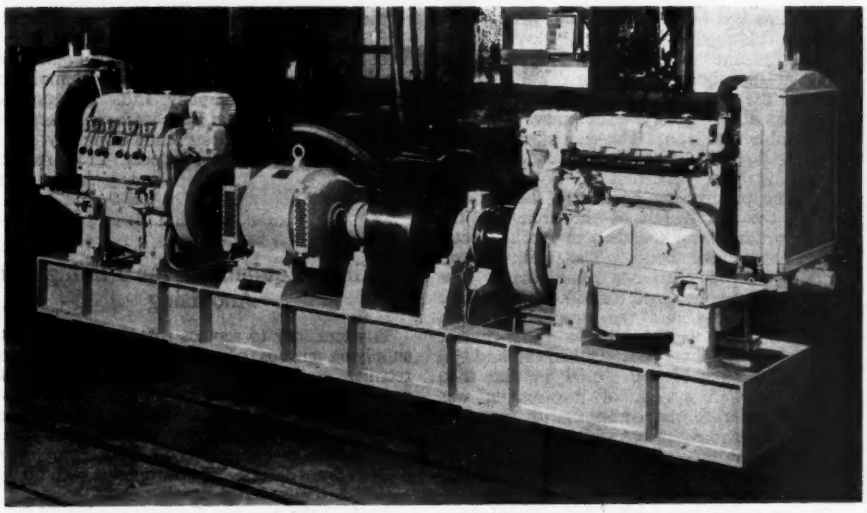
At a recent demonstration, Austinlite, Ltd., Lighthouse Works, Smethwick, 40, Birmingham, showed two versions of " no-break " automatic power plant. One is for use on isolated stations and is intended to run for as long as one month without requiring attention. The other is a stand-by set in conjunction with a normal a.c. mains supply.

The illustration shows the first set which is powered by two Lister " FR " diesel engines mounted at the ends of a welded bed. Between them are located the flywheel and alternator which are connected by a flexible coupling. At the outer ends of the flywheel and alternator shafts are fitted two magnetic couplings, the friction plates of which are flexibly connected to the engine flywheels. Both alternator and flywheel run in ball-bearings and for extra safety in case of bearing failure the flywheel shaft is housed in phosphor bronze clearance bushes. The engines are equipped with dry sump lubrication and protected by a cooling water thermostat and a lubricating oil pressure switch. A governor on each engine maintains the speed within ± 1 per cent of 1500 r.p.m. for operation at 50 c/s, and 1800 r.p.m. for 60 c/s. The clutches allow either engine to be shut down and, if required, to be removed while the other continues to drive the set. A centrifugal switch, belt-driven from the alternator shaft, is used to detect speed variations. The control equipment is mounted inside a separate cabinet and includes ammeter, voltmeter and frequency meter, overload circuit breaker, static exciter and voltage regulator, engine control relays and indicator lamps. Automatic charging equipment for the batteries is separately provided. To start the set, one engine is clutched in and cranked by hand. Change-over to the other engine takes place automatically at preset intervals, or immediately in case of failure of the duty engine, by clutching in the stand-by and driving from the other engine or from the flywheel, until the incoming engine has reached full speed. The duty engine then declutches and stops. Should the incoming engine fail to fire, the drive automatically reverts to the duty engine, and an alarm is operated.

The second kind of set consists of one " FR " diesel engine driving a flywheel and alternator through a magnetic clutch. The engine is started by hand and accelerates the flywheel and alternator combination to synchronous speed, after which the alternator functions as a synchronous motor and the engine is stopped. Should the mains supply fail, the engine will be restarted automatically by the flywheel and take over the drive, while the motor reverts to its role of alternator. The duration of the disturbance is said to vary from 5 to 150 milliseconds depending upon conditions in the mains. As the engine is started, the frequency and voltage will fall by not more than 10 per cent in the first five seconds and will be fully restored within sixty seconds. On restoration of the mains supply, the set is automatically synchronised and the engine stopped. Both sets are stated to maintain the load voltage to within $\pm 2\frac{1}{2}$ per cent and the frequency to within ± 1 per cent.

Technical Reports

Field Tests on Wood Preservatives Used for Pressure Treatment. Forest Products Research Bulletin No. 32, published by H.M.S.O. for D.S.I.R., price 2s. 6d., by post 2s. 7½d.—Field tests on wood preservatives have been carried on at the Forest Products Research Laboratory since 1928. Results obtained up to the end of 1953 on preservatives normally applied under pressure are given in the present publication. At present the only satisfactory method of measuring the effectiveness of preservatives is the field test. It may take ten or twenty years to obtain useful results by this method. Preservatives normally applied under pressure are comparatively few and of two kinds—oils and water soluble salts. The oil preservatives include coal tar creosote and mixtures of coal tar creosote with a mineral oil or with coal tar. Solutions of copper naphthenate or pentachlorophenol in a mineral oil are also used. The principal water-soluble preservatives are various proprietary mixtures of salts available under trade names. The long-term field tests were carried out by treating specimens of wood with the preservatives and setting them about half their length in the ground side by side with untreated controls. The tests were duplicated at three different sites to offset the variation in results caused by locality. Four common home-grown timbers were used, oak and beech representing hardwoods, Scots pine and Douglas fir representing softwoods. Results so far obtained, although not all complete, indicate the general behaviour of the different classes of preservative and those likely to be most satisfactory in use.

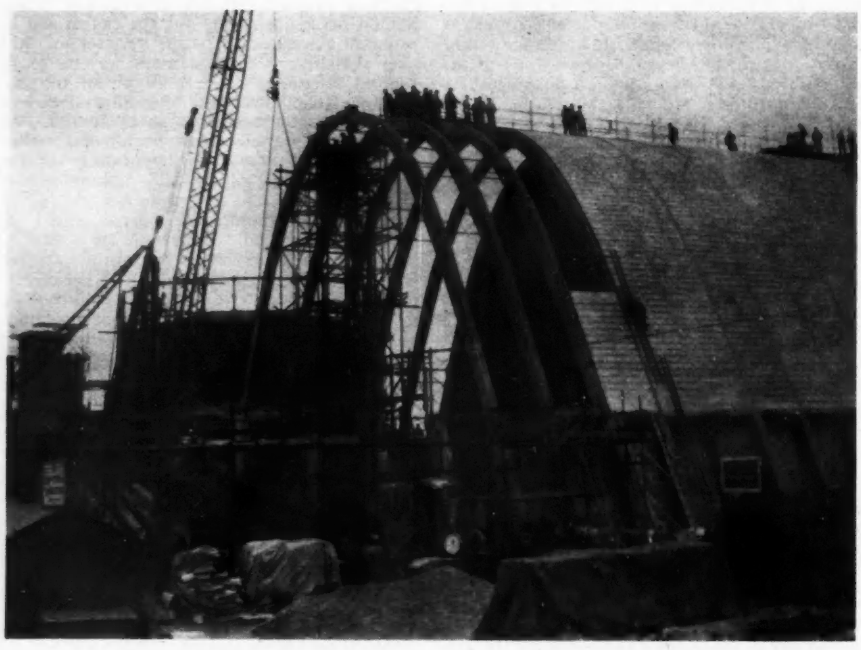


10kW double-engine generator set for maintaining a continuous supply on unattended sites

Prestressed Concrete Storage Building

We illustrate herewith a storage building recently built for the South Eastern Gas Board at Phoenix Wharf, Greenwich, for the storage and handling of ammonium sulphate. The building forms part of the Board's reconstruction scheme at Phoenix Wharf by-products works. Structurally, it consists of a series of three-pinned prestressed concrete arch ribs clad with precast prestressed concrete planks.

The whole building comprises the store, which is 168ft long and 96ft wide, and the bagging house which is 108ft wide and 60ft long. The store is constructed with sloping wing walls 17ft 6in high along two sides, which also act as retaining walls; they are cast *in situ* with buttresses at 8ft centres. Opposing pairs of buttresses in the retaining walls support precast, prestressed three-pin arches, each having a span of 86ft 6in and a rise of 48ft 6in. The arch ribs are 12in wide and vary in depth from 1ft 9in at the ends to 2ft 9in at the point of maximum bending moment. Each rib is 66ft long and weighs approximately 13 tons.



Storage building consisting of three-pinned arch ribs clad with precast planks. The pins at the arch springings may be seen just above the level of the scaffolding in the foreground

The main ribs were prefabricated on the site, the 50ft long central section of each rib was cast on this bed between two factory-made end blocks. This method was used to avoid joints in the ribs and to allow the hinges—rocker hinges at the abutments and a "knife edge" hinge at the apex—to be incorporated in the end blocks at the factory. The hinges are made of malleable cast iron. The end blocks, which had been cast with ducts for the passage of the prestressing bars, were first positioned on the bed; the prestressing bars were then passed through the full length of the arch rib, the centre portion being sheathed in flexible metal tubing to prevent bond. The main central length of rib was then cast round them. The concrete mix was designed for 4500 lb per square inch at ten days and the proportions were 1 : 1·4 : 2·8 by weight with a water-cement ratio 0·38. Sulphate-resisting cement and ¾in maximum aggregate were used in the mix. The Lee-McCall system of prestressing was used and the ribs were stressed with two 1⅛in diameter bars. After stressing the ribs were taken to a storage area on the floor of the store from which they were lifted into position by a derrick with a 117ft jib.

The roof was formed by factory-made pre-tensioned concrete planks supported by the ribs, 7ft 6in long, 12in wide and 3in thick. Steel loops project from the ends of each plank. These loops fit over projecting stirrups on the spine of each rib. Steel bars were passed through the stirrups over the loops to hold the planks in position. The space between the ends of the planks was finally concrete in, the loops and stirrups acting as reinforcement. At the apex of each arch two precast crown slabs span from rib to rib, resting on corbels at the top of each rib. These slabs were tied to each other and to the ribs by seven wire cables stressed on the Gifford-Udall-C.C.L. system. The cables are lapped, spanning from outside to outside of adjacent ribs. A 1in gap was left at the apex between the pairs of crown slabs to preserve the articulation of the arch. The prestressing in the crown provided a tie between the arches until the plank infilling was completed. The roof of the store has an exterior waterproof finish of two layers of a bituminous product "Cromastic Lastic" with a white sea shell dusting applied to the top coat before drying to give a less sombre appearance. The ends of the store building are formed by a reinforced concrete frame with brick panelling.

The design for the store and bagging house was prepared by the central construction department of the South Eastern Gas Board in conjunction with Twisteel Reinforcement, Ltd., who prepared most of the detailed drawings. The contractor for the civil engineering work is the Demolition and Construction Company, Ltd. The precast end blocks and the roof slabs were manufactured by the Liverpool Artificial Stone Company, Ltd., and Anglian Building Products, Ltd., respectively.

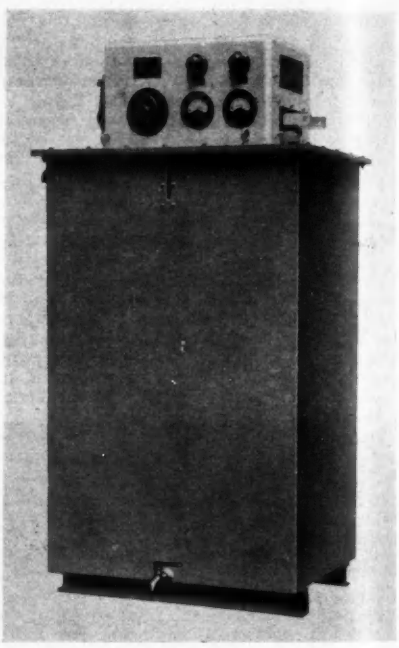
Rectifier Equipment for Plating and Anodising

The tendency to replace rotary generator sets supplying groups of plating vats, by separate rectifier equipments providing individual vat control is exemplified in plant recently developed by The General Electric Company, Ltd., Magnet House, Kingsway, London, W.C.2. Compared with motor generator sets, rectifier equipments such as those described below operate with higher efficiency and reduced running costs.

Each of the new rectifier sets consists of three main components: a variable auto-transformer, a double-wound transformer and a full-wave bridge connected rectifier. The mains supply is taken through a switch and fuse to the auto-transformer, which provides stepless control of the voltage from 0 to the full rated output of the rectifier. From this auto-transformer the output is applied to a double-wound transformer, where it is stepped down to the value required for supplying the rectifiers. The transformer is built in accordance with B.S. 171. A moving coil voltmeter and ammeter, suitably protected against corrosive fumes, allow for measurement of the d.c. output of the rectifiers. To provide for cooling and to combat corrosion, both transformer and rectifier are oil immersed, using clear oil to B.S. 148 Class "B." A thermostat, located near the surface of the oil, sounds a warning bell and switches on a red pilot light if the oil temperature rises beyond a safe limit. The pilot light, bell and Variac control together with the meters are housed in a drip-proof compartment above the tank. Cooling is provided by natural convection. In very large vats circulatory movement of the oil can be increased by providing vertical tubes down the sides of the tank, which increase the area of the tank in contact with the outside air.

To minimise the difficulties caused by accidental short circuiting when the vats are being loaded the output current is limited to not more than 300 per cent of the full-load current, and the rectifiers are designed to withstand this overload for a period of several minutes.

Normally rectifiers are supplied for single-phase working, but for large units three-phase working is preferable, because of the smoother output and higher efficiency. For special purposes, such as chromium plating, three-phase units can be supplied in which the ripple of the output is less than 4 per cent. The smaller units are housed in one case as illustrated, but in the larger units transformer, rectifiers and control gear are housed in separate units. Our illustration shows a 6V, 500A plating rectifier equipment in which the single-phase transformer and rectifier are contained in a plain tank with the control unit mounted on the top.



6V, 500A, plating rectifier set. The tank contains a transformer and selenium rectifier. The control unit is mounted on the lid

The rectifier units described above are designed for operation in an average ambient temperature not exceeding 95 deg. Fah. When required for use in tropical climates the ratings of the rectifier sets are reduced and the ambient temperature correspondingly increased. Tropically rated sets so modified can be operated in an ambient temperature of 131 deg. Fah.

Development of Reheat for Gas Turbines

By J. L. EDWARDS, A.F.R.Ae.S.*

In the following abstracts from the paper which was read before the Royal Aeronautical Society on Thursday, October 21st, some of the problems associated with the use of reheat in aeronautical gas turbines are discussed. The author uses arbitrarily an engine with a mass flow of 250 lb/sec., an output of about 17,000 lb rising to 24,000 lb with reheat. Such an engine would consume 10,000 g.p.h. with full reheat at Mach No. 1·5.

THE modern applications of reheat are to assist the take-off of heavily laden bombers or to force fighters up to supersonic speeds. Fundamentally, only three broad issues are involved in reheat. One is the flow aspect, which in the main is amenable to calculation and is the subject of the theory mentioned above ; this is amplified in this paper to show the effect of forward speed and nozzle expansion ratio. The second is combustion with its many and varied characteristics involving fuel atomisation and vaporisation, stabilisation and stability, extinction limits, and delay and reaction combustion times, all of which can be varied and adjusted *ad infinitum*. Finally, mechanical design whereby a gas stream at pressures up to 80 lb per square inch and temperatures up to 2000 deg. K. must be enclosed in a piece of pipe of negligible thickness and even less weight, and accelerated to supersonic velocities through an infinitely adjustable nozzle with a perfectly smooth profile and no base drag.

For the purpose of quantitative illustrations an arbitrary engine has been selected of mass flow 250 lb per second, pressure ratio 7·5 and compressor and turbine efficiencies of 85 per cent. and 90 per cent respectively. Such an engine would develop about 17,000 lb thrust on the ground, rising to 24,000 lb with full reheat. The fuel consumption without reheat would be 2060 g.p.h. with an extra 4300 g.p.h. for reheat to 2000 deg. K. At an aircraft Mach number of 1·5 at sea level the reheat flow would rise to 10,000 g.p.h.

PERFORMANCE

Sea Level Static Conditions.—When heat is added to a moving gas stream flowing in a parallel pipe it can be shown that the Mach number increases according to the expression :

$$\frac{M_4\sqrt{[1+\frac{1}{2}(\gamma-1)M_4^2]}}{1+\gamma M_4^2}=\frac{M_3\sqrt{[1+\frac{1}{2}(\gamma-1)M_3^2]}}{1+\gamma M_3^2}\sqrt{\frac{T_3}{T_4}} \quad . \quad . \quad . \quad . \quad . \quad (1)$$

and that the total pressure changes in the ratio.

$$\frac{P_4}{P_3}=\frac{1+\gamma M_4^2}{1+\gamma M_3^2}\left[\frac{1+\frac{1}{2}(\gamma-1)M_3^2}{1+\frac{1}{2}(\gamma-1)M_4^2}\right]^{\frac{\gamma}{\gamma-1}} \quad . \quad (2)$$

where subscript (3) denotes conditions before and (4) after heat has been supplied, and

M = Mach number

$\gamma=\frac{C_p}{C_v}$ = ratio of specific heats

P = total pressure.

These equations can be most conveniently expressed graphically, as shown in Fig. 1, and they demonstrate a most important point. If the figures are transposed to show the thrust increase which may be obtained from any given system (Fig. 2), then it is clear that as the temperature ratio or the proportionate thrust boost rises, so the significance of the combustion Mach number increases. At temperature ratios of the order of 1·5 giving about 20 per cent thrust increase, it makes little difference whether the tailpipe Mach number before heat is added is 0·2 or 0·3. At a temperature ratio of 2·0, however, implying a reheat temperature of the order of 2000 deg. K., a tailpipe Mach number of 0·2 will give a thrust increase of 42 per cent whereas at a Mach number of 0·3 the mass so increases that only 32 per cent will be obtained.

Fig. 3 shows a band of reheat combustion efficiencies. It is difficult to generalise the experimental evidence here, since the efficiency is a direct function of the stabiliser configuration, fuel injection arrangements and tailpipe length. None the less, the curve is interesting, in that it shows the order of efficiency which may be expected from an engine of 4 : 1 compression ratio and the general effect of blockage area and tailpipe length.

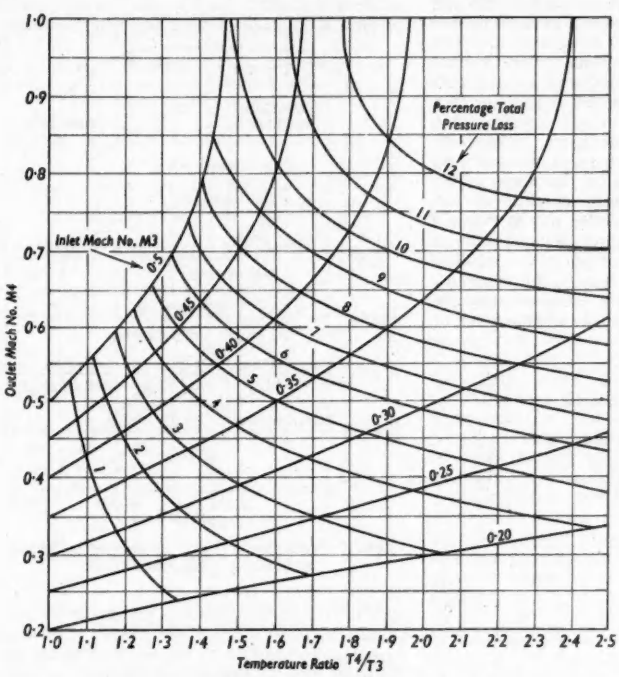


Fig. 1—Gas flow characteristics for combustion in a parallel pipe for various inlet Mach numbers

Flight.—Assessment of reheat performance in flight was exceedingly difficult despite comprehensive instrumentation. Fig. 4 does show the trend and on the whole is probably reasonably accurate. It is difficult to generalise as to what will happen to any intake engine reheat combination under conditions of supersonic flight. In the first place, the intake is assuming an alarming importance and its performance at off-design conditions can have far-reaching effects on the pressure-temperature relationship of the air at the compressor inlet. The engine compressor is working at low equivalent rotational speeds and its efficiency will vary by an appreciable amount. Variable intakes and compressor blades further complicate the flow regime.

Fortunately present experience indicates that the temperature rise through the compressor is virtually constant for a given engine speed, which means that the temperature drop through the turbine also remains unchanged. Assuming constant turbine inlet temperature and efficiency, the temperature ratio across the turbine, and hence the leaving Mach number, are unaffected by changes in the flight conditions.

This fortunate state of affairs obviates what could have been a very difficult problem indeed, namely changes in reheat combustion Mach number during flight.

To emphasise the changes in physical conditions which arise, a number of cycle calculations have been made for the engine rating outlined in the introduction for which compressor characteristics and intake efficiencies have been assumed. These assumptions do preclude a general application of the results, but since the aim is to show the range of conditions under which any reheat system must work this is not important.

Fig. 5 illustrates the probable changes in tailpipe pressure ; the temperature remains approximately constant. The line of demarcation between the engine with thrust augmentation and the ram-jet, where the ram pressure and turbine outlet pressure are equal, occurs at a Mach number of about 3·0 and this is probably the criterion which discriminates between these two forms of prime movers. Admittedly the ram and turbine outlet temperatures have not attained equality, but this can be achieved on the ram-jet by the admission of slightly more fuel.

Considering the high-speed end of the flight spectrum, conditions are not too serious and the pressure and temperature at 60,000ft Mach number 2·0 and over are in a relatively high-pressure region where little difficulty need be anticipated from the combustion system.

At the lower flight speeds which will be used for cruising without reheat, this state of affairs no longer exists. Pressures have dropped to about 5·0 lb per square inch absolute, and in this region combustion can be very difficult, if not actually precarious.

The fact that it is a transient actually makes things worse, since if relatively sudden changes in air/fuel ratio are to be accommodated during the light-up and while the final nozzle is opening, the stability range must be wide.

The effect of intake drag becomes much more marked at high forward speeds, and the net thrust increase due to reheat rises steadily. Fig. 6 shows this change up to a flight Mach number of 3·0, from which it will be seen that the proportionate thrust increase rises from 40 per cent at sea level static to a maximum of 215 per cent at a Mach number of 3·0. At this point the curves steepen, since the whole system tends to become a ram-jet, with the engine doing no useful work.

So far no mention has been made of fuel consumptions, for the deliberate reason that generalisation here is difficult and unreliable. None the less, some attempt has been made to show the general trend (Fig. 7).

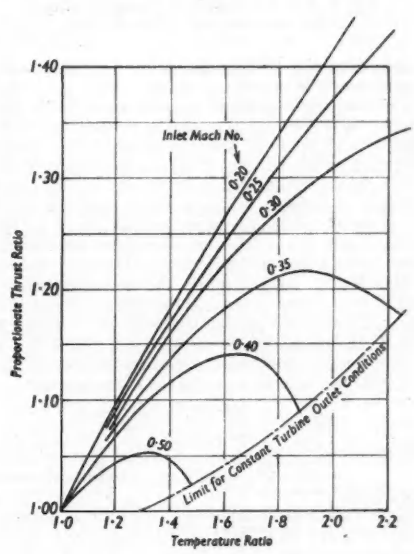


Fig. 2—Variation of thrust ratio with temperature ratio and inlet Mach number (allowing for all losses)

General Design Requirements.—To attain very high forward speeds the maximum thrust available from any given installation will almost certainly be required. This implies the highest

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temperatures attainable from the reheat system, theoretically obtained when the air/fuel ratio through the engine reheat system is stoichiometric. In these circumstances the final temperature would be about 2250 deg. K. and every scrap of available oxygen would have to be used. No shielding or cooling of either tailpipe, the inner cone or the final nozzle would be possible and the combustion efficiency would have to be 100 per cent.

This is obviously a somewhat optimistic state of affairs, unlikely to be realised in practice. At high temperatures it is essential to cool the tailpipe skin and the nozzle, which requires some 10 per cent of the exhaust gases. The combustion efficiency will be between 85 per cent and 95 per cent, depending on the length of the tailpipe, which, at optimum conditions, will introduce some degree of cooling due to unburnt fuel and attainment of the absolute maximum rise will necessitate either a high loss stabiliser system or a very long tailpipe. Allowing for these things, it is generally accepted that the maximum useful temperature is of the order of

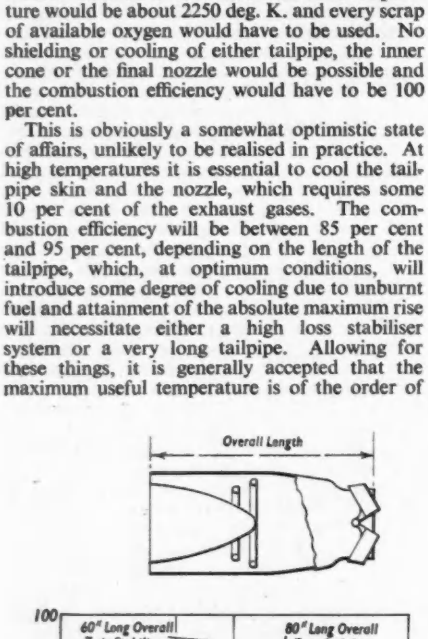

Overall Length
Reheat Combustion Efficiency - Per Cent
60" Long Overall Twin Stabiliser
80" Long Overall Twin Stabiliser
60" Long Overall Single Stabiliser
Temperature Ratio

Fig. 3—Effect of stabiliser blockage area and tailpipe length on combustion efficiency

2000 deg. K., corresponding to a temperature ratio over the tailpipe of about 2·0.

If ever this reduced performance is to be attained, it is essential to design the tailpipe with the lowest possible Mach number in the combustion zone. There is little object in calling for a final temperature of 2000 deg. K. and then trying to achieve it in a gas stream initially moving at a Mach number of, say, 0·30. The losses will be so high as to render the thrust increase in going from, say, 1750 deg. K. to 2000 deg. K. insignificant ; the only change will be a pronounced increase in the fuel consumption. To emphasise this point a typical system reheating to 2000 deg. K. has been analysed, and Table I compares the compound losses for the two cases of 0·20 Mach number and 0·30 Mach number.

TABLE I.—*Table of Pressure Losses*

Reheat Mach No.	0·20	0·30
	Per cent	Per cent
Fundamental combustion loss	2·9	6·1
Diffuser loss	4·2	4·2
Stabiliser loss (35 per cent blockage)	2·7	5·9
Skin friction loss (including heat shield)	0·7	2·3
Heat shield loss	0·5	1·2
Propelling nozzle loss	1·5	1·5
Total loss	12·5	21·2

The effect of a high initial Mach number can be plainly seen. It affects not only the combustion loss, but the skin friction down the tailpipe and heat shield, and the stabiliser loss. In all, the thrust gain is penalised by some 10 per cent.

Suspension in the tailpipe presents a number of problems, none of which is particularly serious, provided that it is borne in mind that there must be freedom of movement for expansion in all directions.

The strength of the outer skin must be adequate under the worst flight conditions with full reheat. From an approximate operating line shown in Fig. 5 the maximum pressure likely to be

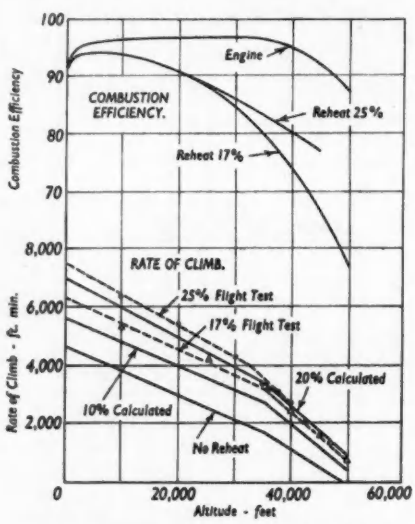


Fig. 4—Variation of reheat combustion efficiency and rate of climb with altitude

encountered in the tailpipe is just under 80 lb per square inch or a differential pressure of 65 lb per square inch. With a 0·1000in thick and a 40in diameter pipe the bursting stress alone is nearly 6 tons per square inch without making any allowance for the tensile loading. This is within the 0·1 per cent proof stress limit for Nimonic 75 at 600 deg. Cent., but if the metal temperature should rise for any reason the safe stress could easily be exceeded. The need for a heat shield is obvious, since without it metal temperatures of the order of 1000 deg. Cent. could occur, which would be prohibitive.

Detail Investigations

[In the following paragraphs which are here considerably condensed, the author goes on to summarise the results of development work on the various components.]

Diffusers.—Much of the pressure loss in any reheat system may be debited to the annular

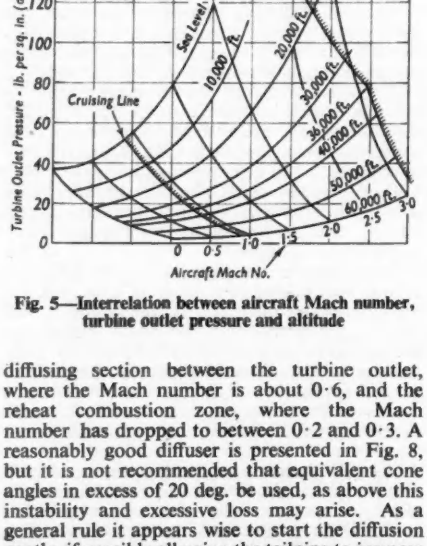
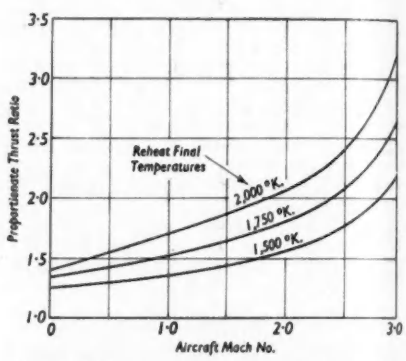


Fig. 5—Interrelation between aircraft Mach number, turbine outlet pressure and altitude

diffusing section between the turbine outlet, where the Mach number is about 0·6, and the reheat combustion zone, where the Mach number has dropped to between 0·2 and 0·3. A reasonably good diffuser is presented in Fig. 8, but it is not recommended that equivalent cone angles in excess of 20 deg. be used, as above this instability and excessive loss may arise. As a general rule it appears wise to start the diffusion gently, if possible allowing the tailpipe to increase in diameter over the turbine size, for a few inches, and then diffusing uniformly to the design Mach number. It is not unusual when reading literature on diffusers to see that much better diffusion can be obtained if a certain length of parallel section is added to the annulus. This is an indisputable fact and with a straight parallel region some 10 per cent greater diffuser efficiency can often be obtained.

Fuel Injection.—Superficially, fuel injection is a relatively easy matter, since atomisation of the fuel is accomplished by the high velocity gas stream in the tailpipe ; in effect an air blast atomiser can be formed by merely injecting a plain jet of fuel at right angles to this gas stream. As the air density falls so will the fuel flow to the exhaust system ; thus the system is to some extent self-compensating and in practice the injection distance does not seem to vary significantly. There is a possibility that this will become important at extreme altitudes and low aircraft speeds, however, and further investigation is essential. Before any liquid fuel can be burned it must be vaporised. This vaporisation takes time, and injection too close to the gutters will cause a slowing down of the early stages of the combustion process. It is thus advisable to position injectors a short distance upstream. The time for a 10 micron droplet to vaporise is approximately half a microsecond, or in a gas stream travelling at 600ft per second a distance of some 4in is sufficient.

Returning to our hypothetical engine, a reheat final temperature of 1750 deg. K. would be achieved on the test bed with an overall fuel/air ratio of 0·0385, of which the engine fuel/air ratio



Normal jet pipe temperature, 1000 degree K unchanged with flight conditions. Gases fully expanded in convergent/divergent propelling nozzle under all conditions. Altitude 36000ft and over

Fig. 6—Relationship between proportionate thrust increase and aircraft Mach number

would be 0·0179. These fuel/air ratios increase to 0·0428 and 0·0182 if allowance is made for 98 per cent engine combustion efficiency and 85 per cent reheat efficiency. In terms of fuel flow 2050 g.p.h. go to the engine and 2760 g.p.h. to the reheat system.

Two techniques are available for fuel injection after the turbine. The first uses spray bars inserted radially into the tailpipe, injecting fuel tangential to circles coaxial with the engine ; the second uses fuel rings coaxial with the stabilisers and injects fuel radially inwards or outwards. There are merits in both schemes, but on average it is felt that the ring distributor is probably slightly better.

It has been suggested by various authorities that injection upstream of the turbine not only gives better atomisation and mixing, as the fuel and air pass through the turbine, but that it also permits combustion to take place without any artificial aid to stabilisation. In other words, the fuel ignites more or less spontaneously as it passes into the tailpipe, and combustion then continues by eddy mixing in the turbulent gas stream passing to the final nozzle. Further, it is claimed that there is some advantage in that the injected fuel cools the turbine nozzles and rotating blades, thus permitting higher combustion chamber temperatures.

The concept of pre-turbine injection is fundamentally wrong. It assumes that the temperature of the gases leaving the turbine is always high enough to maintain combustion in the tailpipe, that no combustion will occur during passage through the turbine and that stability will be unimpaired with changes in flight conditions.

Since it is known that a drop in temperature even on the test bed can result in non-ignition of pre-turbine fuel, the effect at altitude will almost certainly be similar. The only realistic application is one where, on a single-stage turbine, appreciable overheating of the basic engine is permitted, and steps are taken to protect the tailpipe from overheating, distortion and burning. Even then equivalent or better results can be achieved from an orthodox scheme with no increase in weight or complexity.

Stabilisers.—To obtain good combustion—and by that is meant a steady flame with wide stability limits—it is essential to provide a small region where the mean gas velocity can be reduced below the flame speed and where the initial stages of combustion may proceed in a comparatively leisurely manner. The resulting small, very hot region will then mix into the surrounding fuel/air mixture and combustion will proceed until the flame is either quenched by intermingling cool gases, until the local mixture strength passes outside the stability range or until combustion is complete.

At the moment the most successful methods of "stabilisation" are quite orthodox. Some form of baffle is introduced into the gas stream to provoke an eddy reversal and local recirculation and the flame is held to this baffle. If the mixture in the eddy zone should become non-combustible, due possibly to variations in either air flow or fuel flow, then the flame will go out. Several forms of stabilising baffle are in current use, ranging from a multiplicity of small flat plates or cones to a grid of circular gutters, interconnected in a framework.

Combustion.—A number of very interesting papers have been published in the last few years on combustion in high-speed gas streams behind stabilisers. In general, work has been undertaken on homogeneous gaseous mixtures, and though realistic velocities have been attained, in some cases up to 1000ft per second, inlet gas temperatures have been more applicable to ram jets than reheat.

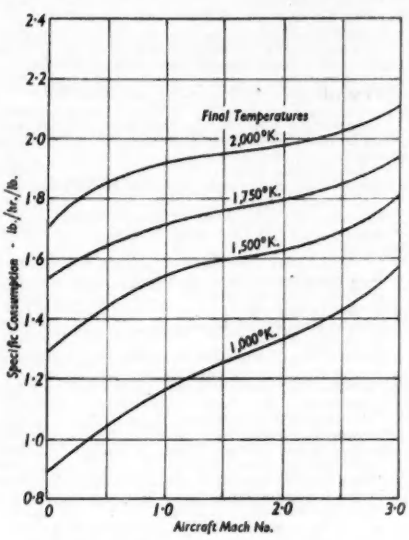
The mechanism of the combustion process is now fairly well understood. A region of eddy reversal is formed behind some sort of baffle, such as a flat plate, V-gutter or a cylindrical rod, and this wake serves to stabilise the flame. Presupposing a uniform fuel/air mixture the initial stages of combustion take place in the circulating region of the wake. These heated gases then accelerate up to and past the speed of the unburnt gases, and the velocity gradients so formed generate vortices on the interface between burnt and unburnt gases, and combustion thus proceeds throughout the mixture. There is a drop in static pressure as the flame spreads, and on completion of combustion the total to static pressure relationship has been changed in such a way as to give the increased Mach number shown on Fig. 1.

Ignition.—So far no mention of ignition has been made, but this can be a major problem. Two techniques are available, either direct electrical ignition by high tension or high energy spark, or by a "streak" where a small quantity of fuel is injected into the combustion chamber, where it ignites, the flame then passing through the turbine and down the tailpipe to the reheat stabilisers.

Screech.—During the course of both reheat and ram-jet development one of the most persistent troubles has been the onset of a high-frequency vibration which has become generally known as "screech." It is characterised by peculiar violence and its onset is invariably followed by rapid mechanical failure. This failure evinces itself by tearing of the sheet metal or, if the screech is only mild, persistent breakage of bolts or slackening of nuts.

While there must be a pattern in the phenomenon, it has so far proved impossible to generalise; it has been experienced in low-temperature installations running at only 15 per cent thrust increase and at high thrust boosts where outlet temperatures of upwards of 2000 deg. K. have been attained. Despite a great deal of work by many people, the exact mechanism of this troublesome phenomenon is not yet known. None the less, a certain amount of knowledge has been accumulated and an attempt will be made to summarise the findings to date.

Before doing this it is worth mentioning the various forms of combustion instability which appear in gas turbine installations. The commonest is a rather rough vibration of low frequency and modest amplitude occurring when the turbine nozzles are unchoked. In this case it is possible that the whole air system vibrates as an organ pipe from intake to final nozzle, and that combustion over-richness induces a resonant condition somewhat on the lines of a singing



All combustion efficiencies assumed to be 100 per cent and gases fully expanded. Altitude 36,000 ft

Fig. 7—Effect of aircraft Mach number on overall specific fuel consumption

flame. The well-known rumble experienced during engine starting and in the early stages of acceleration is probably of this type.

A second form of instability which has been experienced on reheat systems running at high air/fuel ratios is once again of low frequency, and could very well be due to organ piping of the tailpipe alone. It is associated with local over-richness around the stabiliser, and is a precursor of rich extinction. It has been experienced on both the test bed and in flight, and the mechanism is thought to be due to the spasmodic and sudden combustion of local sections of the mixture followed by a quiescent period while the exhaust

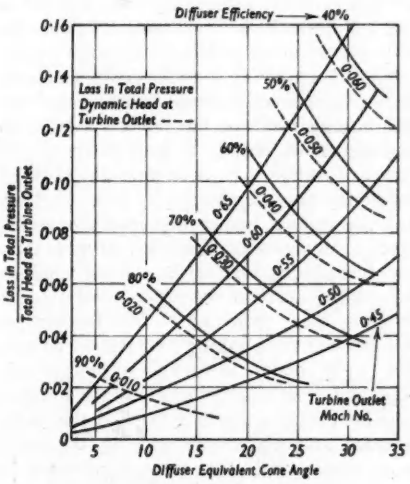


Fig. 8—Tailpipe diffuser performance

gases escape and fresh mixture is supplied, when the cycle repeats. This repetitive process may or may not excite gas resonance, but it will produce roughness, instability and ultimately extinction.

Turning now to the third form of vibration, namely screech, there seems to be little doubt that it is either a longitudinal or transverse gas vibration in the exhaust stream. The amplitude can be very high, and pressure variations of over ±7·0 lb per square inch have been measured on "Ghost" and "Goblin" installations. It is considered unlikely, however, that the sheet metal of the tailpipe is in resonance with the gas frequency, and the failures are almost certainly due to forced vibration.

Propelling Nozzles.—There is little doubt that the fully variable nozzle for use at high temperatures presents one of the biggest mechanical problems associated with reheat. There are, of course, other solutions than those outlined above, but a simple solution of the problems of cooling, weight and control is most elusive. In fact, there seems to be no easy way out, and the complicated mechanisms at present coming on to the test bed may be the only answer.

Fuel Systems.—In a typical engine of 250 lb per second mass flow, for example, a reheat fuel flow of the order of 10,000 g.p.h., would be required at a Mach number of 1·5 at sea level. With quantities of fuel of this magnitude, displacement pumps of any kind are heavy and cumbersome, and the associated gear drives occupy valuable engine space. The centrifugal pump driven by an air turbine has the advantage of compactness and mechanical independence of the engine, allowing it to be positioned more conveniently. Disadvantages of the centrifugal pump are the difficulty of obtaining the fuel pressure, except at high pump speeds, the bulk of the air ducting necessary to convey the turbine air from the engine to the unit, and the low efficiency. It is possible that the efficiency will be improved with development, and that the overall figure of about 30 per cent now being attained may be lifted appreciably. It is unlikely, however, that very high efficiencies will ever be attained, and 50 per cent is probably the optimum.

The power requirements are quite high, and for a 250 lb per second engine reheated to 2000 deg. K. a maximum of about 400 b.h.p. is necessary under sea level conditions at 1·5 Mach number. This can be obtained from about 6·5 lb per second air, after due allowance has been made for losses in the ducting, which implies a loss from the engine of approximately 1·0 per cent.

British Standards Institution

All British Standard Specifications can be obtained from the Sales Department of the Institution at 2, Park Street, London, W.1.

POLYTHENE-INSULATED CABLES, SHEATHED WITH P.V.C. FOR ELECTRIC POWER AND LIGHTING UP TO 250V.

No. 1557 : 1954. Price 5s. This edition supersedes B.S. 1557 : 1949 but deals only with polythene-insulated cables sheathed with polyvinyl chloride. The principal feature of the new edition is the reduction in insulation and sheath thickness which has been found possible as a result of experience since the publication of B.S. 1557 : 1949. Other changes are the inclusion of quality requirements and tests for the p.v.c. sheath and a method for the determination of the grade of the polythene insulation. It has been considered desirable to specify tinned copper conductors as standard, the main advantages being ease of jointing and resistance to corrosion. The standard reference temperature of 20 deg. Cent. has been adopted as in other recent British Standards for cables. It should be noted that the 250V cables specified in this standard are deemed to be suitable for use on a three-phase, 440V system having its neutral point solidly earthed. Among the Government departments and other organisations represented on the committee responsible for the preparation of this standard were the Admiralty, the General Post Office, British Electrical and Allied Industries Research Association and Cable Makers' Association.

CARBON BRUSHES (PARALLEL-SIDED) FOR USE ON COMMUTATOR AND SLIP-RING MACHINES

No. 96 : 1954. Price 2s. 6d.—This revised standard applies to carbon, graphite and metal-graphite brushes, with the exception of those used in aircraft. Because the various brush sizes have been revised the identification numbers of the brushes included in the 1938 edition have been altered. In addition, some extension of scope has been possible and a range of brushes such as are commonly used on commutators of traction motors has been added. The specification is intended as a step towards the ultimate standardisation of brushes, and preferred sizes are given for adoption wherever possible.

THE ENGINEER

Vol. 198 NOVEMBER 5, 1954 No. 5154

LEADING ARTICLES—
Institution Collaboration ... 634
Soviet Rocket Development ... 635
ARTICLES—
British Cast Iron Research Association ... 617
Combined Heavy Turning and Profiling Support (Illus.) ... 641
"Comet" Court of Inquiry ... 617
Continuous Spur Gear Grinder. (Illus.) ... 640
Continuous Supply Automatic Power Plant. (Illus.) ... 629
Deep Shell Mould Making Machine. (Illus.)... 644
Development of Reheat for Gas Turbines. (Illus.) ... 631
Development of the Steam Turbine. (Illus.) ... 623
Diffused Lighting System ... 643
Europe's Oil Production and Consumption ... 617
Hand-Operated Thrust Borer. (Illus.) ... 644
Improved Copying Technique for Drawings ... 641
ndustrial Fluorescent Lighting Fittings. (Illus.) 644
Industrial pH Amplifier and Electrode Assemblies. (Illus.) ... 643
Institution of Civil Engineers: Presidential Address ... 620
Institution of Production Engineers ... 641
International Pressure Die Casting Conference 617 and 640
Joint Iron Council ... 617
Light Structural Steel Section. (Illus.) ... 639
Marconi College. (Illus.) ... 628
Mechanised Cultivation and Harvesting of Sugar Beet. (Illus.) ... 638
Miniature and Sub-Miniature Precision Potentiometers ... 628
Pacific National Exhibition, Vancouver, British Columbia ... 643
Plate Mill, Kembla Works, N.S.W. ... 639
Prestressed Concrete Storage Building. (Illus.) 630
Railway Reorganisation ... 617
Rectifier Equipment for Plating and Anodising. (Illus.) ... 630
Scrap Baling Press. (Illus.) ... 641
Stress Concentrations at Holes in Rotating Discs. (Illus.) ... 618
Works Extensions ... 643
AMERICAN SCENE—
Atoms for Peace ... 646
St. Lawrence Power Project. (Illus.) ... 646
One Cubic-Yard Shovel-Crane with Hydraulic Controls... ... 646
Three-Hinged Arch Hangar at Pittsburgh. (Illus.) ... 647
Experimental Gas Turbine Test Plant. (Illus.) 648
Brake Material Testing Dynamometer ... 648
LETTERS TO THE EDITOR—
Broad-Flanged Beams ... 637
Non-Dimensional Groups and the Model Laws of Dynamic Similarity ... 637
Economy in Construction of Power Stations ... 637
LITERATURE ... 636
OBITUARY—
Sir Wallace Akers, C.B.E. ... 635
Sir John Lennard-Jones, K.B.E. ... 635
Dr.-Ing. Franz zur Nedden ... 635
NEWS AND NOTES—
African Engineering News ... 642
Book of Reference ... 641
British Patent Specifications. (Illus.) ... 651
British Standards Institution ... 633
Canadian Engineering News. (Illus.) ... 645
Catalogues ... 652
Forthcoming Engagements ... 652
Indian Engineering News ... 642
Industrial and Labour Notes ... 649
Launches and Trial Trips ... 650
Notes and Memoranda ... 650
Personal and Business ... 650
Technical Reports ... 629

INSTITUTION COLLABORATION

Of recent years the Institutions of Civil, Mechanical and Electrical Engineers have increasingly shown a tendency to consult together and to act in common. That trend was already apparent between the wars. But it was not very strong. Indeed, one of the more notable examples of joint action in the early 'thirties related to the activities of graduates and students rather than councils. It was the founding amongst the graduates and students of the Young Trophy competition, a competition benevolently looked upon by the councils of the Civils and Mechanicals and actively encouraged by Mr. H. T. Young, at that time a vice-president of the Institution of Electrical Engineers. He presented the trophy which bears his name within (if we remember rightly) two years of the playing of the inaugural cricket match at which the Electricals team inflicted a crushing defeat upon a joint team of Civils and Mechanicals. It was the war and the important activities it fostered amongst the Institutions which brought the three major bodies into a co-operation much closer than had ever before existed, with the consequence that what before the war was merely a growing habit has now become a matter of established custom. Like the members of the Commonwealth each Institution maintains its own individuality, its own freedom of action; but in fact none now acts in any matter likely to affect all three without consulting the others.

A very recent example of the development of common action is provided by the decision of the Mechanicals to join with the Civils and Electricals in the holding of a joint Part I examination. This project was first seriously studied some years ago; and at that time the Civils and Electricals reached agreement. But the Mechanicals, though sympathetic, could not reach agreement with the others about the subjects in which a student must, at that stage of his education, prove his proficiency; and felt unable, therefore, to join in. The fact that now, only a few years later, the difficulties seem to have evaporated should not, however, be held too critically against that Institution. When bodies like the three Institutions have existed for very many years as separate entities, not without past mutual jealousies, and have created their own customs and usage in many activities, it is asking much that they should change them. In particular it is asking much when the benefit to themselves is slight. For in the matter of Institution examinations it *is* slight. Relatively few students take those examinations. The large majority secure exemption. Indeed it could be argued, not without a good deal of force, that the prime purpose of an Institution examination is less to provide a path towards membership for students unable to exempt themselves, than to set up standards of attainment; and to inform educational bodies about the Institution's views on the subjects a budding engineer must master at progressive stages in his education if he is to have any hope of qualifying for membership. It is students and educational bodies that reap the advantage of a common examination, far more than the Institutions themselves. It is a minor advantage that those few students who desire to enter more than one of the Institutions are relieved from taking two sets of papers. The really major advantage is that at colleges and other establishments all the students can be brought together to take the same lectures and classes and to do the same experiments with the same equipment, a matter of great administrative convenience. Moreover, when the new arrangements for the joint Part I examination, are studied it will be found that the difficulties that hindered earlier agreement have been not so much overcome as evaded. For example, alone amongst the three Institutions the Mechanicals insist that "Engineering Drawing" should be a compulsory Part I subject, having for long considered that no mechanical engineer can be properly educated without a sufficient mastery of this subject. Similarly, the Civils lay so much stress upon proficiency in "Theory of Machines" and "Theory of Structures," even at this early stage of a civil engineer's education, that a pass in one of them is regarded as essential. The Electricals are content with proof of proficiency only in the five other subjects upon which all three Institutions are agreed. Furthermore, the Mechanicals in order to leave undisturbed a course of study that has proved very satisfactory have had to include the two subjects "Applied Heat" (or "Heat Engines") and "Workshop Technology," which find a place in National Certificate courses, as exempting from a subject in the Joint Part I examination "Heat, Light and Sound," which quite clearly covers substantially different ground. In short, difficult compromises have had to be made and the agreement between the Institutions is not complete.

We have laid stress here upon the educational achievement of a joint Part I examination as an example of Institution co-operation because it so well reveals both the method of the co-operation and the nature of the difficulties that may sometimes have to be faced. The first task before any action can be taken is to survey the ground so that each Institution is fully informed about the opinions and practice of the others. Points of similarity can then be studied to see whether fuller agreement can be reached. Lastly, there must often and inevitably be good-tempered agreement to differ where practice and opinions are found to be, or are thought to be, too divergent. To those with orderly impatient minds agreements to differ may seem merely a kind of escapism, a hiding of the head in the sand. Such agreements would, we feel, be anathema to a foretime regular contributor to our correspondence columns who advocated a very complete federation of the engineering institutions. But for our part we think differently. It is not sheer optimism to suppose that time solves disagreements. For once bodies like the Institutions, with many aims and objects in common, become accustomed to co-operation the members of each council, almost automatically, react against any proposed course of action divergent from that of the other bodies; and in favour of any action towards convergent policies. Thus as changes are inevitable with time the bodies concerned drift towards a closer accord, just as much as they consciously pursue it. The very fact that some years after a failure of the Mechanicals to co-operate educationally with the Civils and Electricals a means has been found of evading the difficulty illustrates our point. The same patient method of concentrating attention on points of agreement is also proving its value in the cordial relationships which the major engineering institutions are building up with similar bodies in the Commonwealth and those working in the Western European countries. It is not folly to "play down" disagreement; it is wisdom. Along that way collaboration lies. After all there is no need, when enjoying a round of golf, to remember that one's friendly adversary and collaborator is also for other purposes a bitter political opponent!

SOVIET ROCKET DEVELOPMENT

The liquid propellant rocket, like other modern inventions with a military application, has reached its present advanced state of development largely as a consequence of the stimulus given by war and preparations for war. Without this stimulus the large sums required for investigation and research would not have been forthcoming. Since the early years of the century pioneers have been discussing the rocket as a means of interplanetary travel but it was not until the early 'thirties that the German and Russian armies began investigating the possibility of its development for military purposes and set up their own establishments for investigation and research. At the end of World War II the more modern and better equipped German rocket factories and test stations fell into Russian hands and it is estimated that over 160 German rocket experts were induced or compelled to work for the Soviet Government. Recent reports in the Soviet press and Moscow broadcasts give some indication of the progress already made in Russia. Soviet scientists are stated to be giving increasing attention to interplanetary travel and to have designed rockets which reached a height of 240 miles. The dispatch of a "stratoplane" to the moon in the near future has, it is claimed, now become a possibility. Mr. G. P. Sutton, an American aerophysicist, who has made an exhaustive examination of reports from refugee officers and engineers and other sources considered reliable, estimates that the Soviets have a stockpile of more than 1000 improved "V.2s," with a range of 400 miles—nearly twice the range of the original missiles used to bombard London.

There are reports also of a very much larger two-stage rocket with a range of some 2000 miles, but it seems unlikely that a missile of this size would be worth while developing for practical use in war. Even the German "V.2" required a total of nearly 10 tons of alcohol and liquid oxygen for its range of 220 miles. None the less, the fact must be faced that Russia may be in a position to carry out a full-scale attack on Britain—the country which is essential as a base for offensive operations by the N.A.T.O. powers—with rockets that already exist. Whether or not these rockets will have atomic warheads, they are capable of inflicting immense loss of life and destruction if used in adequate numbers. The primitive and unguided German "V.2" killed nearly 2000 and seriously injured 6000 people during the six months the German army was able to use it before being over-run by the Allied forces. The Soviet practice is always to play down the strength of conventional forces and to boast of progress in nuclear weapons while at the same time pressing for a ban on their manufacture. It has been known for some time that Russia has had an army of 175 divisions and 30,000 tanks, and recently the Admiralty disclosed that since 1945 there has been built up a powerful surface and underwater navy and naval air arm of thirty cruisers, 150 destroyers and 4000 naval aircraft. All this seems to indicate that the Soviet Government, realising that distance and resources would be against her in an atomic war with the United States, hopes that nuclear weapons will not be used except in retaliation and does not intend to be the first to employ them. Poison gas, it will be remembered, was not used by Hitler because of his fear of retaliation.

In the United States, Government sponsored liquid propellant rocket research started in 1942 and in Britain only after the war. In both countries first importance has been attached to the development of anti-aircraft guided missiles, but the United States has also spent considerable sums in investigating the long range rocket. The "Corporal"—a development of the "V.2," is already in service in the U.S. Army and is also being tried out in the British Army. It is a 5½-ton rocket, 40ft long and 3ft in diameter and is credited with a range of from 60 to 100 miles. A battery of ten "Corporal" launching platforms with their transporters is being sent to Germany at the end of this year. The Americans are also developing the pilotless bomber, two types of which—the "Matador" and "Regulus"—are in service to-day in the United States Air Force and Navy, respectively. These missile carriers have a range of 200 to 300 miles and can be launched from large aircraft, surface ships and submarines well clear of hostile anti-aircraft defence. However, given early radar warning, anti-aircraft guided missiles and supersonic fighters, the missile carriers are no less liable than piloted bombers to be shot down, as is proved by the "V.1" losses during the war. There is little ground for believing that the Soviets are developing to any extent either the pilotless bomber or the large aircraft required to launch them. All available evidence suggests that with the aid of German equipment, "know-how" and expert technicians, they are concentrating on the development of guided rockets as a long-term policy. Equally with the British Minister of Supply, they no doubt believe that in the reasonably near future no bomber will be able to hope to outmanœuvre the anti-aircraft guided missiles now under development. And they may well have thought it best, in planning for several years of cold war, to devote their main effort to the production of a missile—with or without a nuclear warhead—whose speed of 4000 miles an hour and a trajectory in the upper atmosphere seem to defy any counter which is conceivable to-day.

Obituary

SIR WALLACE AKERS, C.B.E.

We regret to have to record the death of Sir Wallace Alan Akers, which occurred on Monday last, November 1st, at his home at Yiedyn, Kings Road, Alton, Hants. Sir Wallace, who was sixty-six, was director of atomic energy research in the Department of Scientific and Industrial Research from 1941 to 1946.

He was educated at Aldenham School and at Christ Church, Oxford, and began his scientific career in 1911 with Brunner Mond and Co., Ltd., at Winnington. In 1924, Sir Wallace took up an appointment with the Borneo Company, but he returned to the chemical industry in 1926, when Brunner Mond and Co., Ltd., became part of Imperial Chemical Industries, Ltd. He went to the Billingham works in 1931 and in 1941 he was appointed to the board of Imperial Chemical Industries, Ltd. At the same time his services were lent to the Department of Scientific and Industrial Research, where he took charge of a special technical committee engaged on atomic energy research. Sir Wallace relinquished this position in 1946 in order to resume full-time duty with Imperial Chemical Industries, Ltd. He continued, however, to render many services to the D.S.I.R. and was appointed to its advisory council in 1952. Last year, Sir Wallace served upon the committee which, under the chairmanship of Lord Waverley, was entrusted with the task of formulating the proposals which led to the setting up of the United Kingdom Atomic Energy Authority.

Sir Wallace was elected a Fellow of the Royal Society in 1952, and he was also a Fellow of the Royal Institute of Chemistry. He was created C.B.E. in 1944 and received his knighthood two years later.

SIR JOHN LENNARD-JONES, K.B.E.

We note with regret the death of Sir John Edward Lennard-Jones, which occurred in hospital at Stoke-on-Trent last Monday, November 1st, at the age of sixty. He became Principal of the University College of North Staffordshire last year.

Sir John was educated at Manchester University and at Trinity College, Cambridge, and obtained a D.Sc. degree at both universities. In the first world war he served with the Royal Flying Corps, and from 1919 to 1922 was a lecturer in mathematics at Manchester University. Subsequently, Sir John became reader in mathematical physics in the University of Bristol, where, in 1925, he was appointed Professor of Theoretical Physics. In 1930, he became Dean of the Faculty of Science at Bristol University, and two years later moved to Cambridge on being appointed Plummer Professor of Theoretical Science. Sir John remained there until he took up his appointment last year at the University College of North Staffordshire. During the second world war there were many demands upon Sir John's scientific services. He was chief superintendent of armament research and director-general of scientific research (defence) in the Ministry of Supply, and in 1942 he was appointed to the advisory council of the D.S.I.R. From 1947 until last year, Sir John served as chairman of the Ministry of Supply scientific advisory council.

Sir John was elected to Fellowship of the Royal Society in 1933 and a year ago was awarded the Davy Medal by the Society. He was also a past-president of the Faraday Society. The honour of K.B.E. was conferred upon Sir John in 1946.

DR.-ING. FRANZ ZUR NEDDEN

Engineers in many countries, who have an interest in the work of the World Power Conference will learn with regret of the death in Berlin on Saturday, October 23rd, of Dr.-Ing. Franz zur Nedden, secretary of the German National Committee. Dr. zur Nedden, who died in his seventy-fourth year, was a valued member of the Verein Deutscher Ingenieure, practically throughout the whole of his career. He was a close collaborator of the late Dr. Conrad Matschoss, the director of the Verein, and assisted him with editorial and publishing work. He also served on many of the technical committees of the Verein. Shortly after the end of the first world war, zur Nedden was called to serve the German Government in the distribution of its coal and fuel supplies, and was appointed a departmental chief and secretary of the

Technical and Scientific Committee formed to advise the Government on its fuel problems. That special work brought him in close touch with the mining industry, its technical institutions and distributors and users of fuel.

When in connection with the First World Power Conference held in London in 1924 it was decided to form a German *ad hoc* committee to promote German participation, zur Nedden was elected deputy secretary and he held the same position in the Permanent German National Committee. The late Dr. Conrad Matschoss was the secretary for many years, but his work as director of the V.D.I. and his many literary activities prevented him from devoting as much time to the work of the World Power Conference as his deputy. It thus came about that zur Nedden was the most active honorary officer of the Second Plenary World Power Conference, held in Berlin in 1930, when 3891 members took part. Although he did not hold the title, he became in effect the honorary organiser of that conference. In the years which followed, zur Nedden continued to attend in unbroken sequence all the plenary and sectional meetings of the World Power Conference, and those of its International Council.

After the second world war he was present at the Fourth World Power Conference, held in London in 1950, and the Delhi Sectional Conference of 1951. In the July of that year Western Germany was readmitted to the World Power Conference as a permanent organisation and Franz zur Nedden was elected secretary of the National Committee for the German Federal Republic, a post he continued to hold up to the time of his death. He attended the meeting of the International Executive Council in Chicago in 1952, and the meetings in Germany which took place at Essen and Düsseldorf in 1953. He was not well enough, however, to attend the recent Brazilian Sectional Meeting of the Conference, or the 1954 meeting of the International Executive Council, which also took place in Brazil.

Dr. zur Nedden continued his close association with the Verein Deutscher Ingenieure when it was re-established in Düsseldorf, and he was entrusted with the publishing of the technical journal *Brenstoff-Wärme-Kraft* "*BWK*," which is jointly owned by the Deutscher Ingenieure Verlag G.m.b.H., Dusseldorf, and the Springer Verlag Berlin.

Dr. zur Nedden learnt to know England and the English language when in his early days he worked in Cornwall as an engineer for a company operating tin mines. His work for the engineering industry both at home and abroad, was recognised by the Verein Deutscher Ingenieure in 1951, when he was awarded the V.D.I. Mark of Honour. In 1954 he received from the German Federal Republic the Service Cross of its Order of Service, for his international work on power problems. Those who were privileged to know him personally and to work with him will long remember his particularly warm and charming personality, which won for him many friends among his foreign colleagues.

INDUSTRIAL WELFARE SOCIETY.—The Industrial Welfare Society has announced that its eleventh annual conference for directors and senior executives is to be held on Wednesday, Thursday and Friday, December 8th, 9th and 10th, at 48, Bryanston Square, London, W.1. Mr. John Marsh will preside at the conference sessions, the general theme for discussion being "Some Management Priorities." The Society has also announced a course for newly-appointed supervisors and chargehands. It is to be conducted at 48, Bryanston Square, London, W.1, from Tuesday to Friday, November 30th to December 3rd, the aim being to create an awareness of basic principles of good management and human relations on the shop floor.

Literature

The Scientific Basis of Road Design. By F. L. D. WOOLTORTON. London : Edward Arnold (Publishers), Ltd., 41, Maddox Street, W.1. Price 60s.

IN this country the ready availability of adequate supplies of strong quarried stone and gravel has considerably simplified road construction, although in recent years engineers have increasingly appreciated the value of a knowledge of the properties of soils and of means of increasing their stability in order to achieve economic road designs. In overseas areas there is often a complete absence of good road-making materials and sometimes the behaviour of soil foundations is unusual, especially where the climatic conditions are severe. When road construction has to be carried out under such conditions experience obtained in this country is not enough and it is then essential that the engineer should have an adequate knowledge of the basic properties of soils if satisfactory, all-weather roads are to be built.

The author of this new volume of the well-known Roadmakers' Library has had many years of experience of road engineering in the British colonial service, and this has enabled him to appreciate fully the importance of an adequate knowledge of soil mechanics and soil stabilisation in relation to road construction. He has clearly made a careful study of the literature on these subjects, and in this book he presents the results of this study with the stated object of providing road engineers with the essential information required in road design, particularly for low-cost road construction overseas. While the aim of the author is thus entirely to be commended it is considered that, possibly through over-enthusiasm for his subject, he has entered into a consideration of soil behaviour at a more fundamental level and in more detail than is required to convey the information that the road engineer needs in order to carry out his duties satisfactorily. This excessively fundamental approach may well lead readers to conclude that soil mechanics is a far more complex subject than it really is, and may thus defeat the whole object of the book. It has also led the author into a discussion of some problems which have not yet been adequately investigated, and on which there is likely to be disagreement about the views expressed. Few attempts are made in the book to illustrate in detail how a knowledge of soil properties is interpreted in terms of road design, and it would perhaps have been preferable for more attention to have been given to this aspect and to have treated the soil properties themselves rather less fundamentally.

The book will prove of greatest interest to research workers and to materials engineers who already have an advanced knowledge of soil mechanics. As already stated, it is to be expected that many road engineers will find the treatment to be too complex to make the book of assistance to them in their day-to-day work.

Relaxation Methods. By D. N. DE G. ALLEN. London : McGraw-Hill Publishing Company, Ltd., McGraw-Hill House, 95, Farringdon Street, E.C.4. Price 53s. 6d.

THIS book is for those who want to learn how to carry out the relaxation solution of a problem which has already been formulated in mathematical form, but which it is either impossible or impracticable to solve by analytical methods. It is not concerned with the theory of relaxation or approximate numerical methods in general, nor with the theoretical background of the examples chosen or which may arise in using the method ; other books are available for those with such academic interests, including, of course, the original treatises of Sir Richard Southwell ; but the reader who conscientiously works through this book will indeed have a sound grasp of practical relaxation methods and should be capable of applying them to new problems and also be able to benefit more from those papers which extend the method to new fields.

In spite of its concentration on teaching how to carry out relaxation, however, this is no mere recipe book or set of computational rules ; fundamentals are always clearly laid down and difficulties carefully explained, although it would naturally take the tyro considerable practice before he were able fully to benefit from Mr. Allen's explanations. This is partly because of the unfamiliarity of the procedure to most engineers and partly because in the interests of readability the examples are chosen to be relatively quickly solved. The author does warn his readers that they are in for "dirty work," but they may not appreciate the tedium inseparable from much of the practical application of the work. Relaxation methods are not, of course, alone in this respect ; any numerical approach to a difficult problem is bound to be laborious and other methods do not always share the ability of relaxation to remove at one stroke the accumulated computational errors to date.

The scheme of the book is well designed for those who intend fully to master the method ; starting easily with the relaxation approach to sets of ordinary linear algebraic equations, the first physical application is to framework problems, that is, to the Hardy-Cross case. The use of finite difference approximations for differentials is then introduced and examples are solved for ordinary differential equations and Laplace and Poisson's equations. Here the practical instruction becomes more detailed as the problems become less obvious, as, for example, in the application of square nets to curved boundaries, and in the difficult case of normal-gradient boundary conditions. Here a straightforward, if laborious, method is preferred to the more elegant method of Fox (cited by the author), and this is typical of the practical approach of the whole book : there is no doubt, in our opinion, that in ordinary hands the method here given is superior in practical value.

After examples on quasi-plane potential problems, and biharmonic problems, simultaneous differential equations are dealt with. In this part of the book the examples are necessarily more complex and in some instances the reader is referred to the original papers for the solutions ; it is unfortunate that the *Proc. Roy. Soc.* are not so freely available to students and practising engineers as to make such references altogether easy.

After a note on triangular nets, the book goes on to deal with eigenvalue problems governed by both algebraic and differential equations. To us this part was the most interesting section of the book, particularly since we were not fully seized of the power of relaxation methods in this connection. Both the orthodox Rayleigh approach and the intensification method are fully explained and illustrated with examples drawn from vibrating strings, beams and membranes, buckling of struts, whirling of shafts and a reference to the application of the method to electromagnetic vibrations in wave guides. The reader is, as has already been said, expected to have the necessary mathematical physical and engineering back-

ground to understand the nature of the problems; given the prerequisites, these two chapters are very well done.

The book ends with a chapter on internal boundary problems and two rather difficult chapters on problems involving unknown boundaries and on the so-called "non-elliptic" differential equations. These can with advantage be omitted on a first reading, although they contain valuable material. Finally, there is a short chapter on three-dimensional problems. There are four useful appendices dealing with standard procedures; in particular, Appendix III giving the usual finite difference approximations for low order derivatives, should be available separately to be kept on every relaxational computer's desk. The bibliography gives the principal references to the publications by Sir Richard Southwell, his school and his disciples; the application of relaxation methods by others is less adequately dealt with.

The book is strongly recommended to all who want to learn how to apply relaxational procedures.

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

BROAD-FLANGED BEAMS

SIR,—I note under the "American Scene" in the current issue that under the heading of "Wide-Flange Beam Rolling Mill," your American editor mentioned the "Mill designed by Henry Grey for the rolling of wide-flange structural sections."

One could almost read into this that Henry Grey was an American. Also, that Mr. Charles Swab was responsible for the development of the above.

I think on investigation you would find that although broad-flanged beams were not rolled in Great Britain fifty years ago, they were used and supplied from Grey Mills operating on the Continent.

JNO. A. THORNTON

Huddersfield,
October 30th.

NON-DIMENSIONAL GROUPS AND THE MODEL LAWS OF DYNAMIC SIMILARITY

SIR,—In books on dimensional analysis much emphasis is given to the so-called π-theorem without mentioning the specific limits of this theorem. Therefore, it is not surprising that serious fallacies have occurred in papers dealing with the representation of test results of investigations based on non-dimensional groups. Curves showing the relationships of such groups over limited ranges are quite often generalised and equations are derived without specifying their limits of applicability. Furthermore, there seems to be a tendency to establish equations which comprise products of powers of non-dimensional groups. It should be understood that the π-theorem cannot define the equation specifying the various non-dimensional groups. The latter method of presentation may be correct in a limited field of application, e.g. in heat transfer problems where it seems to have originated. Any extension to other problems should not be attempted without a careful analysis of the resulting implications.

However, more serious misconceptions may arise from the π-theorem in so far as insufficient explanation of the meaning—as specified in classes 1 to 4—of the resulting various and distinct types of non-dimensional groups can be obtained from the theorem itself. Analysing the suitability of several groups related to a special problem of model investigations, the writer came to the conclusion that some of the groups which purport to be related to model laws cannot be so classified. During a comprehensive search for a rational treatment of this subject only one pertinent publication was found. Even this article by the late Professor M. Weber* seems to include several errors resulting from the π-theorem with regard to a concise classification of non-dimensional terms.

Expanding and correcting Weber's scheme the following classification of non-dimensional groups may be useful, viz.:

(1) Groups forming model laws of dynamic similarity, e.g. the Reynolds number.

(2) Groups forming dependent variables, but not model laws, e.g. the Nusselt number.

(3) Groups consisting of several physical properties only, e.g. the Prandtl number.

(4) Parameters, or ratios of two quantities only, e.g. the area ratio of contracted conduits, venturis or orifices.

Distinct definitions of the main group forming model laws can only be achieved by a series of axioms and certain laws of formation, viz.:

(*a*) The velocity term is an essential variable in a non-dimensional group establishing a dynamic model law.

(*b*) Quantities to be included are determined by the number and type of measurement operations characterising the phenomenon to be investigated.

(*c*) Only the minimum number of variables required for a complete representation of the phenomenon should be included in the group.

(*d*) The fundamental quantities, namely, M, L, T and θ (temperature) should be represented by positive or negative integral powers, including zero.

(*e*) The quantities of point (*d*) are expressed in terms of velocity, length, density and specific heat only.

(*f*) Dynamic model laws are related only to $vl\rho$-functions, which are directly proportional to quantities like viscosity, surface tension, heat conductivity, velocity of sound and acceleration of gravity.

(*g*) Non-dimensional groups, including basic terms of dynamics like force, energy or power, do not form model laws, but may be dependent variables as mentioned above under class (2).

(*h*) All groups which are related to model laws are entities and no mathematical operation is permissible which would change the essential character of those entities. No new model law is formed, apart from those already established in the five following tables, by interrelating several non-dimensional groups.

Keeping those rules in mind, three tables can be established including all MLT—or $vl\rho$—terms respectively. Tables I(*a*) and II(*a*) are distinguished from the others by the fact that they do not include the terms M and ρ.

TABLE I

$ML^{-1}T^{-1}$	$vl\rho$	$\frac{vl\rho}{\mu}$ = Reynolds number
ML^2T^{-3}	$vl^2\rho$	Mass rate of flow
MLT^{-1}	$vl^3\rho$	Impulse (momentum)
ML^2T^{-1}	$vl^4\rho$	Action

TABLE II

$ML^{-1}T^{-2}$	$v^2\rho$	
ML^2T^{-2}	$v^2l\rho$	$\frac{v^2l\rho}{\sigma}$ = Weber number
MLT^{-2}	$v^2l^2\rho$	Force
ML^2T^{-2}	$v^2l^3\rho$	Energy

TABLE III

$ML^{-1}T^{-3}$	$v^3l^{-1}\rho$	
ML^2T^{-3}	$v^3\rho$	
MLT^{-3}	$v^3l\rho[\times\theta^{-1}]$ ...	$\frac{vl\rho c}{\lambda}$ = Péclet number
ML^2T^{-3}	$v^3l^2\rho$	Power

TABLE I(*a*)

L^0T^{-1}	vl^{-1}	$\frac{vl^{-1}}{f}$ = Strouhal number
LT^{-1}	v	$\frac{v}{v_0}$ = Mach number

TABLE II(*a*)

LT^{-2}	v^2l^{-1}	$\frac{v^2l^{-1}}{g}$ = Froude number

* M. Weber: "Das Aehnlichkeitsprinzip der Physik und seine Bedeutung für das Modellversuchswesen," *Forschung Ing.-wesen*, Vol. 11 (1940), pages 49–58.

In contradistinction to Weber and in accordance with the statements (*a*) and (*h*), neither the Prandtl number nor the Grashof number can be called a model law of dynamic similarity. Considerable confusion seems to exist regarding the Grashof number, which, according to Weber, is related to the square of the Reynolds number and may also be expressed as a function of the Froude number. Our scheme shows that the Reynolds number and the Froude number are quite distinct by the place they occupy in two separate systems. Their way of formation shows that they have no direct similarity.

The writer hopes that this short survey of non-dimensional groups may assist particularly the engineer in choosing correct terms for model investigations.

F. V. A. ENGEL

Workington,
Cumberland,
August 26th.

ECONOMY IN CONSTRUCTION OF POWER STATIONS

SIR,—In your issue of October 8, 1954, Mr. G. A. Plummer mentioned the report of the Committee of Inquiry into Economy in the Construction of Power Stations (1953), and mentioned specifically the possibilities of reducing costs on the mechanical engineering side. It was also suggested in the White Paper that considerable saving could be made by the installation of induced draught cooling towers, thus avoiding the heavy costs of the more generally used parabolic tower with natural draught. It was stated by the committee of inquiry that there are now few remaining potential sites where sufficient river water can be obtained for "straight-through cooling" of modern stations and, as a result, future cooling must, they believe, come mainly from cooling towers, and experience in the United States, as well as industrial practice in this country, indicates that mechanical draught towers offer advantages in some cases. In fact, the erection of a large mechanical induced draught cooling tower has recently been completed for the British Electricity Authority at its Hackney power station.

DEREK J. TOW,
B.Sc. (Eng.), Dipl. Chem. Eng.

London, E.C.1,
October 19th.

Books Received

The Gyroscope Applied. By K. I. T. Richardson. London: Hutchinsons Scientific and Technical Publications, Ltd., Stratford Place, W.1. Price 30s.

Elementary Engineering Science. Third edition. By A. Morley and E. Hughes. London: Longmans Green and Co., Ltd., 6 and 7, Clifford Street, W.1. Price 8s.

Fundamentals of Electric Log Interpretation. By M. R. J. Wyllie. U.S.A.: Academic Press, Inc., 125, East 23rd Street, New York 10, N.Y. Price 3 dollars 60 cents.

Atomic Energy and its Applications. By J. M. A. Lenihan. London: Sir Isaac Pitman and Sons, Ltd., Pitman House, Parker Street, Kingsway, W.C.2. Price 22s. 6d.

Heat Transmission. Third edition. By W. H. McAdams. London: McGraw-Hill Publishing Company, Ltd., McGraw-Hill House, 95, Farringdon Street, E.C.4. Price 61s.

Lightning Protection for Electric Systems. By E. Beck. London: McGraw-Hill Publishing Company, Ltd., McGraw-Hill House, 95, Farringdon Street, E.C.4. Price 52s.

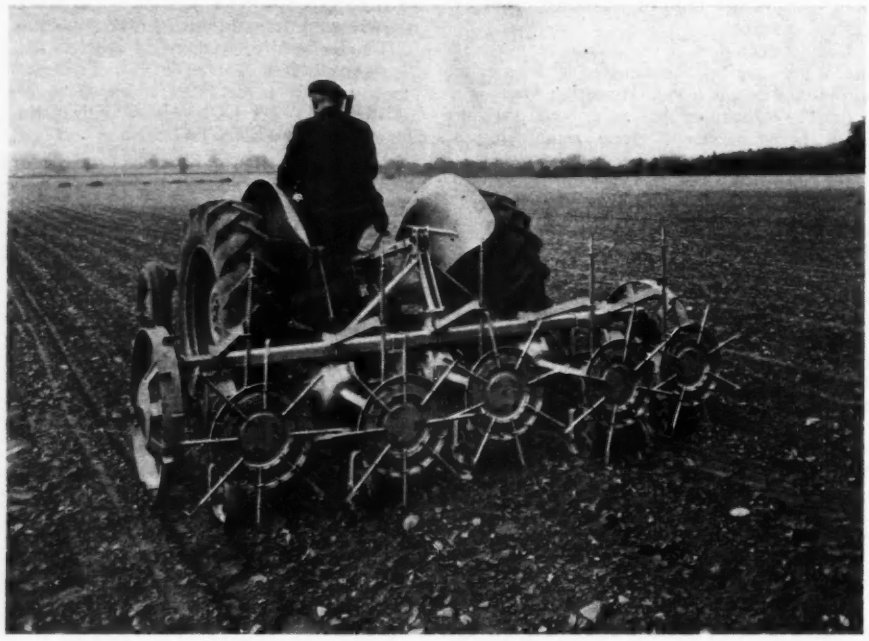
Textbook of Illuminating Engineering. Second edition. By J. W. T. Walsh. London: Sir Isaac Pitman and Sons, Ltd., Pitman House, Parker Street, Kingsway, W.C.2. Price 28s.

Soil Mechanics Related to Building. By J. H. G. King and D. A. Creswell. London: Sir Isaac Pitman and Sons, Ltd., Pitman House, Parker Street, Kingsway, W.C.2. Price 16s.

Chemical Engineering Instruments and Control Methods. General editor, E. Molloy. London: George Newnes, Ltd., Tower House, Southampton Street, Strand, W.C.2. Price 21s.

Mechanised Cultivation and Harvesting of Sugar Beet

THE sugar beet harvest is now in full swing in Great Britain, and it has been estimated that from the 416,000 acres devoted to this year's crop about 4,500,000 tons of beet will be obtained. This is a little below the average for the last five years, the highest yield in that period being reached last year when from 402,000 acres the total quantity of beet procured was 5,275,159 tons. From that the actual production of white sugar was 719,684 tons, the beet being processed in the eighteen factories which are operated by the British Sugar Corporation, Ltd., in various parts of Great Britain.



"Down the row" thinning machine for sugar beet. As the machine travels forward the cutting heads rotate across the rows of plants

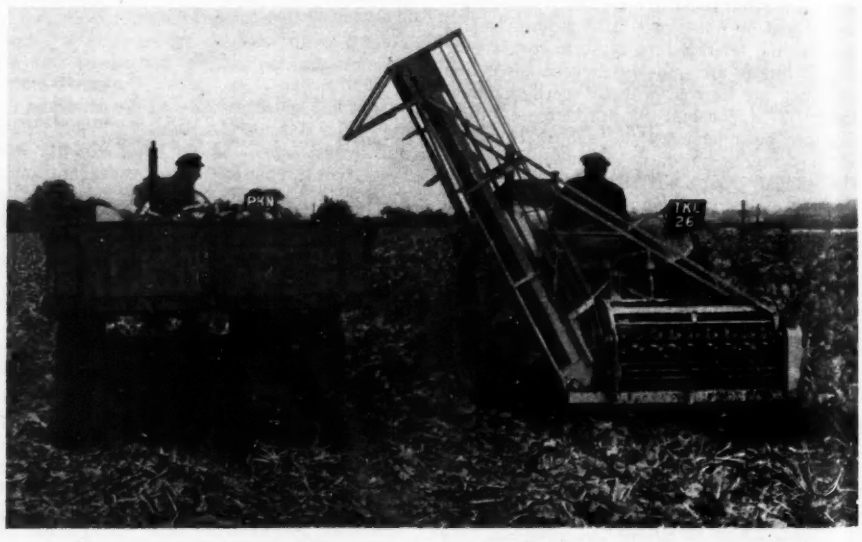
The beet crop is one that requires harvesting as quickly as possible, normally in the months of October, November and December. Although a considerable amount of hand labour is still employed, in recent years progress in the mechanisation of the harvesting operation has been rapid. Last year, for example, 3185 harvesting machines were at work, compared with 118 in 1946, the result being that 30·4 per cent of the total crop was harvested mechanically, compared with 0·9 per cent in 1946. This year, it is expected that 36 per cent of the beet acreage will be mechanically harvested, and it has been estimated that, if the present rate of progress is maintained, the figure will increase to nearly 70 per cent by the harvest of 1960. The mechanical harvesting of sugar beet has thus overcome most of its teething troubles, and the machines which are now in regular production, and many of those still in the prototype stage, are steadily proving their ability to operate efficiently under adverse conditions. This, of course, is an important consideration when, as so often happens, a large part of the harvesting has to be done in unfavourable weather.

The progress of mechanical beet harvesting has received much encouragement from the machinery demonstrations which have been organised annually since 1946 by the British Sugar Corporation, Ltd., with the co-operation of the National Agricultural Advisory Service. The object of these demonstrations is to direct the attention of agricultural machinery makers to the requirements for the job of beet harvesting and, at the same time, to provide an opportunity for beet growers to see, under working conditions, the performance of the machines which are being developed and produced. This year's demonstration has just been concluded at Metheringham, near Lincoln. There, on "medium" land, fairly free from stones, in a heavy crop of beet, eighteen different harvesting machines were shown in the "production class" and six others—not all of them complete harvesters—were shown in the prototype and development class. In addition, there was a representative selection of elevators and loaders at work on part of the harvested crop, some silage equipment for cutting up and loading the beet tops, some one-way ploughs to demonstrate the best method of preparing ground for the growing of beet, and a static exhibition of precision drilling and cultivating machinery.

This last-mentioned class of machinery is becoming increasingly important to sugar beet growers, and in the last two or three years the advances in what is called "spring-time mechanisation" have undoubtedly facilitated the mechanised harvesting of the mature crop. The average plant population of sugar beet is usually about 20,000 to the acre; the seeds are drilled in clusters, sometimes eight or more seeds being sown for every plant required. Precision drills have been designed to deposit clusters of seeds at regular intervals in the row, and some of these machines were described in our issue of April 24, 1953. But with precision drilling there is still a good deal of work involved in thinning the crop in the early stages of the growth of the plants. This, again, is an operation in which much manual labour has been—and still is—employed, though use of machines for the task is steadily advancing.

One of the machines which was shown in the static exhibition at Metheringham is illustrated herewith. It is a "down the row" thinner which is made by Kenneth Hudson and Son, Darlaston, Staffs. The machine is arranged for attachment to the three-point hydraulic linkage of most tractors, and the model illustrated can deal with five rows of plants at a time. The cutting heads are so designed that as the machine travels forward its main wheels, driving through bevelled gears, rotate the heads across the rows of plants. The cutting heads are made with a central boss into which forged steel tines are fitted. For the first thinning operation, eight tines are fitted to each head, as shown in our illustration, and eight "thinning strokes" are thus made in one revolution. In a second thinning operation, sixteen smaller tines are fitted to each head so that a further reduction in the plant population is effected, a normal final result being ten plants in each 100in of row. The cutter heads can be easily adjusted along the square shaft to accommodate row widths from 18in to 28in.

In the harvesting of sugar beet it is essential not only to lift the crop from the ground but also to remove the top leaves and "crown" of each individual beet. Furthermore, the processing factories require the harvested crop to be as free from dirt as possible. These desiderata have had to be kept very much in mind in designing mechanical harvesters, and certainly a good measure of success has now been achieved. Some growers favour the use of two machines, one for removing the tops and the second for lifting and cleaning the beet, and at this year's demonstration there were again some examples of this method. The greater problem in mechanical harvesting, however, is in the design of machines for carrying out the whole of the job in one operation. A combined harvester must top, lift and clean the beet and then either leave it in heaps or rows on the



Tractor-mounted sugar beet harvester. This machine tops and lifts the crop from the ground and loads it on to an accompanying vehicle

ground or elevate it into a conveyance travelling alongside. At the recent demonstration there were more than a dozen complete harvesters at work in the production class. The majority of them are designed to deal with one row at a time, and our observation of their operation bears out the comment made by the British Sugar Corporation, Ltd., in its latest report on mechanical harvesting, that "the topping efficiency of some machines is now well up to the best hand work standards." The lifting mechanisms of these complete harvesters also operated successfully, and in the last year or two there have certainly been improvements in the cleaning and conveyor systems.

One of the more recent British beet harvesters is illustrated. This machine, which deals with one row at a time, has been designed by G.W.B. Farm Machinery, Maxey, Peterborough, and is manufactured by Fisher Humphries and Co., Ltd., Pershore. The lifting and cleaning part of the harvester is mounted on the three-point linkage of a tractor, but the topping mechanism is assembled underneath the tractor, just behind the front wheels. This unit consists of a power-driven "feeler" wheel with a serrated edge, beside which there is a fixed topping knife. Immediately behind the topping knife there are rotating rubber fingers to clear the severed tops into single windrows. The lifting of the beet from the ground is effected by vee shares and there is a double chain elevator which takes the beet to fabricated steel rotating cleaning cages. The rotary action of these cages knocks off the extraneous dirt from the beet which then pass to a chain and finger elevator for delivery into a vehicle moving alongside. The drive to the topping unit is by chain from the power take-off shaft of the tractor; a universal shaft from the power take-off providing the drive for the lifting and cleaning part of the machine. The working depth of the lifting shares is controlled by two adjustable pneumatic-tyred wheels.

Plate Mill, Kembla Works, N.S.W.

THE opening recently of the new plate mill at the Kembla Works, Australian Iron and Steel, Ltd., marks another stage of the company's extensive development scheme and brings closer to realisation the goal of Australian self-sufficiency in the supply of all steel products.

The plate mill produces high-quality plates varying in thickness from $\frac{3}{16}$in up to 4½in, in widths from 24in to 80in and in lengths up to 60ft. Up to ¾in thickness plates can be supplied with edges sheared to close tolerances; over ¾in to 1in sheared on ends only. Edges and sides of plates over 1in in thickness are flame cut. The sequence of plate production begins at the slab yard. Here slabs from the Kembla Works bloom mill are received in 80-ton capacity wagons. The slabs range in size from a maximum of 45in by 8in by 105in, weighing 9835 lb for heavy plate production to a minimum size of 27in by 4in by 81in, weighing 2478 lb, for narrow plate production. They are inspected and reconditioned as necessary before being stocked ready for use in the plate mill. Over 30,000 tons of slabs can be accommodated in this capacious yard. Before rolling in the mill the slab is charged into a slab furnace, 88ft long, to be heated to the rolling temperature of 2250 deg. Fah. A 40-ton pile of slabs is raised to the level of elevated roller tables, on to which they are pushed singly by a rack pusher. The roller tables carry the slab to the furnace, into which it is charged by a heavily powered rack pusher. The pusher moves the whole line of slabs in the furnace until a heated slab emerges from the other end of the furnace on to a set of roller tables leading to the mill. The furnace, rated at 90 tons per hour capacity, has heated on occasion over 100 tons per hour. It is fired with coke oven gas piped from the coke ovens 1½ miles away, and air preheated in recuperators.

The hot slab is run into the vertical scale breaker, consisting of two 42in diameter vertical rolls powered through a reduction gearbox by a 1000 h.p. a.c. motor. Here the slab is reduced in width by some 2in, causing the furnace scale to crack and lose its cohesion. The loosened scale is blasted off the slab by a series of high-velocity water jets at 1500 lb per square inch pressure. The mixture of scale and water falls into a drain running under the length of the mill. Some 4000 gallons per minute of fresh water are used for mill cooling. This also passes into the scale drain and then to scale pits, where most of the scale settles out. It is next pumped into a settling pond, whence it is recirculated to the mill cooling and descaling systems. From the vertical scale breaker the slab enters the horizontal scale breaker. This is a rolling mill with two horizontal 37in diameter rolls driven through the usual pinion stand and reduction gearbox by a 1500 h.p. a.c. motor. This mill breaks up any remaining scale, which is blasted off the slab by a further set of descaling sprays. The high-quality plate produced on the new mill is due largely to the great care taken to ensure as complete and thorough scale removal as possible. The slab, after descaling, enters the broadside mill. This mill is of massive construction, having roll housings each weighing 126 tons, carrying four rolls totalling some 180 tons. Two rolls, of alloy cast steel, are "back-up" rolls, running in oil film Morgoil bearings. The other two are alloy cast steel "work" rolls mounted on 28in diameter tapered roller bearings, driven at 24 r.p.m. through pinion stand, reduction gearbox by a 3500 h.p. a.c. motor running at 500 r.p.m. The back-up rolls ensure that the work rolls will not bend under the extremely heavy loads encountered during rolling. The broadside mill is 130in wide, to enable a fairly long slab to be "broadsided" across its length, spreading its width to the required plate width. This is necessary to roll plates over 45in wide, as this is the widest slab provided by the modified bloom mill in the existing steel plant. Mechanisms are provided to turn the slab through 90 deg. before entry and back again after rolling, and also to push the slab into the mill.

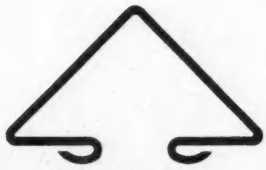
When the slab has been "broadsided" the edges are no longer true and square. A slab squeezer is therefore used to squeeze on the sides of the slab to correct the width for entry into the reversing roughing mill attached edger rolls. The slab passes from the slab squeezer into the reversing roughing mill, in which the slab is reduced to the final thickness required. It is driven through a pinion stand by a 7000 h.p. d.c. motor supplied from an Ilgner generating set. An attached edging mill is provided on the ingoing side to control the slab and plate width, and to enable rolled edge plates to be produced for the first time in Australia. This mill is also fitted with heavy side guards on both sides of the mill to control the plate during rolling. A novel feature of the reversing roughing mill is the automatic preset screwdown, the first of its kind installed in Australia. This enables the operator to preset the screwdown controls which adjust the gap between the rolls for every pass listed in the rolling schedule for the particular plate being rolled. After the plate is rolled in the first pass the operator merely presses a single button and the rolls are automatically adjusted to the setting required for the second pass. This process is repeated until the plate has been rolled to its final size. At the same time the automatic preset screwdown controls the movement of side guards and vertical edging rolls in accordance with the rolling schedule, thus relieving the mill operator of much of the effort involved in operating the mill. The automatic preset screwdown results in improved accuracy and consistency in gauge, with greater rapidity in mill operation.

The plate to this stage has completed its rolling and it now passes from the runout roller tables over a transfer into the plate finishing department Here it is "tailored" to the customers' exact requirements as to length and width. The plate is flattened by going through a roller leveller, which consists of two sets of small horizontal rollers, after which it is conveyed on a disc roller table to a guillotine shear, in which the front end is cropped off and the plate is sheared into approximate length multiples. It is next thoroughly inspected at a roller table designed specifically for this purpose. The table is equipped with a turn-up mechanism so that the underside of the plate may be examined. Next the plate may be side piled, if desired, or sent on for further processing in side trimming and end shears. The side trimming shears, equipped with rotary blades, cut plates up to ¾in thickness and in widths from 24in to 72in. The end shears, placed after the side trimming shears, are fitted with a measuring gauge which enables plates to be sheared in any length from 5ft to 50ft with a high degree of accuracy. From the end shears the plate is run out on roller tables, side piled, classified and stocked ready for dispatch. Each shear in the plate finishing department is equipped with a scrap disposal system, consisting of apron conveyors, scrap choppers and scrap buckets. This avoids all manual handling of scrap, which is sent to the steelmaking departments.

In addition to the production units described above, a considerable amount of auxiliary equipment essential to the mill operation has been provided. The descaling system has been briefly described. The lubrication systems are even more extensive. All back-up roll bearings are supplied with oil by pumps from tanks located in the basement. Oil coolers are incorporated in the system to maintain the correct oil temperature; steam heaters located in the tanks heat the oil during cold weather. Centrifuges are available to minimise water contamination of the oil, while filters eliminate any solid matter. All main drive gearboxes, pinion stands and screwdown gearing are supplied by two similar systems, some 2500 gallons of oil being required to charge these systems. Over 4400 bearings and sliding parts are individually and positively lubricated with grease from twenty-one grease systems, each consisting of tank, pump, lines, &c. In addition, all roughing mill roller tables are on separate oil systems, located under the mill floor at various points. A modern highly productive quality rolling mill, of which the new Kembla mill is a good example, demands an ever increasing number of such auxiliary units to service it.

Light Structural Steel Section

WE have received from Imex Engineering, Ltd., 257/263, Eglinton Street, Glasgow, C.5, details of a cold rolled triangular steel section intended for light structural usage. The shape of the "Trisec" section, as it is called, is shown in the accompanying diagram, the two sides of the triangle including the right angle each being 2$\frac{3}{16}$in in length. The section is supplied in 20ft lengths and the steel thickness is 16 gauge;



Triangular steel section

it is made in mild steel or galvanised steel but is also supplied in aluminium.

The clip-shaped ends of the section are intended to give rapid erection by largely eliminating fixings. For instance, four "Trisec" lengths may be joined, back to back, or as an open box, by inserting 16 gauge angles in the clips; a joggle plate may be inserted to fix plates to the angle section, or alternatively a 16 gauge plate can be pushed into the clip.

MEDIUM-DUTY TRUNKING.—A smaller version of its existing distribution system has been put on the market by The General Electric Company, Ltd., Magnet House, Kingsway, London, W.C.2. It consists of metal-clad sections, 12ft long, containing two, three or four copper busbars. Fused tap-off units may be fitted at 2ft or 3ft intervals. The busbars are supplied for 75/100A and for 150/200A capacity.

Continuous Spur Gear Grinder

LAST week we witnessed a demonstration of the "Heligrind" spur gear grinder which has been developed by Stuart Davis, Ltd., Much Park Street, Coventry. The machine is designed for the quantity production, to B.S.I. Class A.1. standards, of straight spur gears up to 4in diameter by 3in face width in the range 50 D.P. to 20 D.P.

Grinding is done continuously, on the basic rack generating principle, by a wheel which is crush-formed to a single-start spiral rib. Besides being suitable for pre-cut blanks, the machine is, it is stated, capable of grinding gears and

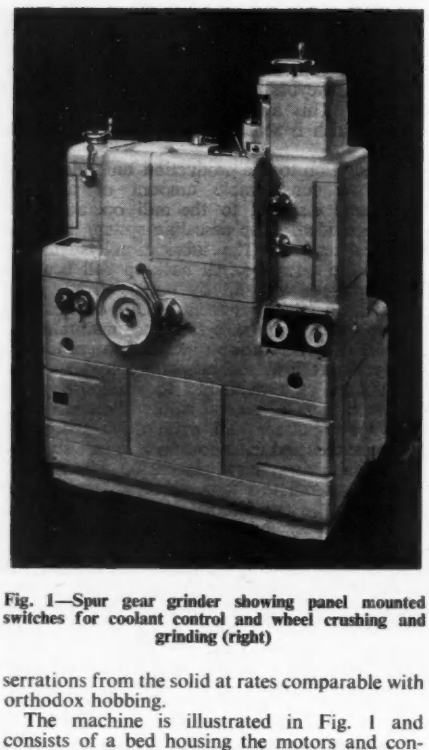


Fig. 1—Spur gear grinder showing panel mounted switches for coolant control and wheel crushing and grinding (right)

serrations from the solid at rates comparable with orthodox hobbing.

The machine is illustrated in Fig. 1 and consists of a bed housing the motors and controls as well as the coolant pump and tank. The horizontal wheel spindle is mounted in precision ball bearings and is belt-driven by interchangeable vee pulleys. Slow and fast rotation, for crushing and grinding respectively, is obtained from two electrically interlocked motors equipped with an over-drive coupling.

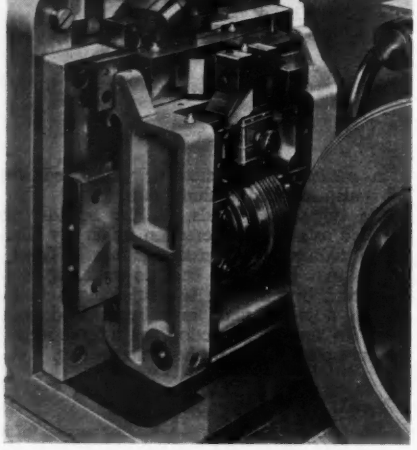


Fig. 2—Crushing roller on hinged frame giving cam-actuated in-and-out movement for crushing and return stroke. The traverse is governed by the sine-table mounted on the vertical slide behind

The wheel head is mounted on a vee-and-flat side which allows it to be moved either towards the crushing roller on the left or towards the work on the right.

After dressing by means of a diamond fixture and suitably narrowing the face width, the form is crushed by feeding the wheel against an annularly grooved roller (see Fig. 2). The roller traverses across the wheel face under the action of interchangeable pick-off gears, and an adjustable sine-table ensures the high accuracy of pitch required. Any change in pitch can be obtained by adjustment of the machine without the use of special equipment such as cams. A constant in-and-out movement allows the roller to engage for the crushing stroke and disengage for the return stroke. In order to obtain maximum life from the rollers, crush-forming from the flat is done in two stages by a soft and a hard

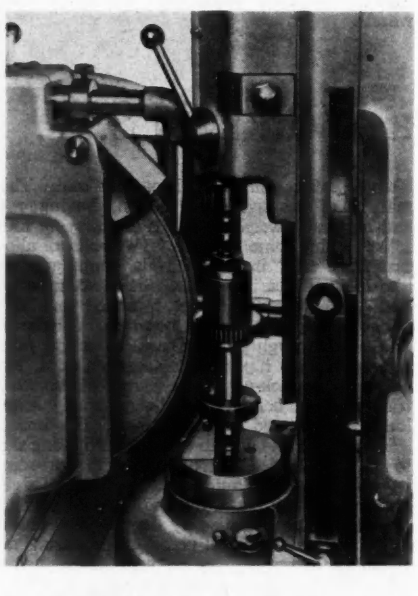


Fig. 3—Gear blank being ground continuously by wheel rotating in a fixed ratio with the work which is fed vertically upwards

roller, the latter being left in position for dressing the wheel periodically as it becomes glazed with use.

The blanks to be ground are mounted on an arbor between vertical centres, Fig. 3, or they can be mounted in collets or in a chuck. The work is fed upwards over the wheel while both revolve in a fixed ratio, thus producing a finish-ground gear in one pass. Seven rates of feed are provided, from 0·0025in to 0·040in per revolution. A side cut control allows pre-cut work to be meshed correctly with the wheel during cutting, by advancing or retarding the work by up to half a pitch. Repeat items can then be set up readily by using a simple fixture.

International Pressure Die Casting Conference

AT the first International Pressure Die Casting Conference, which was held in London last week, five main papers were read and discussed by delegates from a number of countries.

The first paper, which was read by Mr. H. R. Haag, was entitled "Desirable Trends in Die Casting Machine Development," and in it the types of machines at present available were first discussed. The second part of the paper dealt with suggestions for improvements in machines. The author put forward his ideas for the kind of machine which would give fast cycling, safe locking, optimum plunger speed and pressures, simple single-lever control, controlled cycling and ease in setting up. Dealing with die-locking, the author said that a separately arranged device, pneumatically or hydraulically operated was required. This device should provide for automatic compensation for thermal expansion, balanced or unbalanced, in die and machine members. It should also be capable of rapid adjustment for varying die height requirements and should react directly against the machine frame or the tie bars.

Later in the paper, Mr. Haag dealt with cycle controls and pointed out that although at first sight the complete elimination of electrical gadgets was not an easy matter, an obvious solution would be the adoption of sequence or pilot valves, but these were not completely trouble-proof, so that an alternative was desirable. Cam-operated balanced valves could be designed to incorporate the desired properties of short stroke, large volume throughput, and low operating resistance. Where sequence of operation was important, such as interlocked safety, pre-loaded valves which could not be opened against the line pressure could be arranged, these valves to open against low resistance after cracking the line pressure by means of an interlocked pilot valve. Sequence operation of the machine cycle from a single lever or wheel could be variably arranged to cater for different set-ups, including core pulling, by the simple means of interchangeable cams on a single shaft.

In his paper on the "Technical Testing of Pressure Die Castings," Mr. G. Lieby first dealt with the reasons for faulty castings and then described methods of material testing, dimensional tests, strength tests, non-destructive testing and inspection in the production shops.

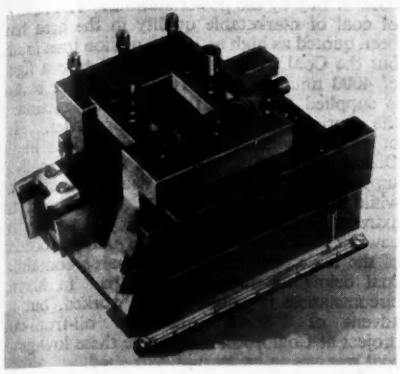
Mr. H. Patin presented a paper on "A Comparison of Die Casting with Machining, Pressing and Plastic Moulding." He gave examples of parts which could be more economically produced by die casting than machining. Then, with reference to stamped parts in sheet metal, the author expressed the opinion that the cost of a pressure casting could generally be reckoned as higher than that of the sheet steel assembly which it replaced, unless the latter was very complicated. Die casting had better chances in the case of a complex assembly which had to be carried out in costly or difficult steel, or in non-ferrous sheet. He thought that, in the face of the severe competition from stamping, the pressure casting industry should pay attention not so much to faster and cheaper production as to making the final assembly better and cheaper. Plastic products had certain advantages over pressure die castings in the fields of fancy goods, cheap toys and household goods, and in the electrical and chemical fields. Mr. Patin said, however, this did not mean that die castings could not find a place in the making of luxury articles, and wherever the need was for mechanical resistance, including resistance to vibration, or good local electrical conductivity, together with a coating for thermic or electrical insulation or for corrosion resistance.

A paper by Messrs. A. P. Fenn and L. A. J. Lodder dealt with the finishes which were available for pressure die castings in zinc, aluminium and magnesium alloys, and the final paper presented to the conference by Mr. F. G. Woollard discussed "Productivity and Pressure Die Casting." Mr. Woollard pointed out that 60 per cent of the die castings produced in the world were of zinc and 30 per cent were of aluminium. So far as mechanical properties were concerned, there was little to choose between zinc and aluminium, but closer limits of accuracy were obtainable with zinc. In the course of his paper this author dealt in detail with the properties and advantages of pressure die castings and the ways in which the industry could extend its markets.

SIMPLIFICATION IN PRACTICE.—The British Productivity Council has published the second in its series of "action pamphlets." It is entitled "Simplification in Practice" and has been prepared by Mr. Bertram White, deputy managing director of A. Boake Roberts and Co., Ltd. Simplification, the pamphlet says, is a "powerful tool" with which British industry can lower its costs, maintain quality and service and hasten delivery. Simplification, it is urged, can be used on particular productive methods, leading to saving of materials and the saving of machine time and man-hours. The particular aspect of simplification dealt with in the pamphlet is defined as "the process of reducing the number of types and varieties of products" made by a firm. The pamphlet, which costs 1s., is available from the British Productivity Council, 21, Tothill Street, London, S.W.1.

Combined Heavy Turning and Profiling Support

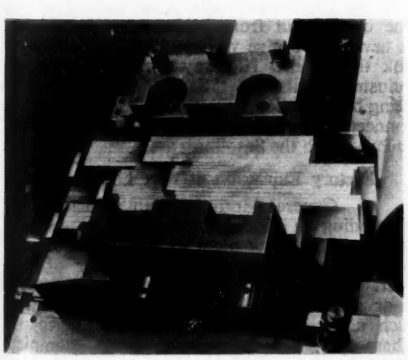
A TURNING and profiling box support of great rigidity has been developed by H. A. Waldrich G.m.b.H., Siegen/Westphalia. The design is stated to be applicable to lathes of



Profiling support showing tool in position, with further supports for turning or parting tools on either side. A depth gauge is attached

more than 500mm centre height. Provided the machine has sufficient rigidity and power, surfacing, grooving and profiling to within a few tenths of a millimetre of the final size can be undertaken at the maximum cutting speed which the material of the tool will permit, leaving only a light finishing cut to be taken afterwards. In the turning of profile rollers for rolling mills, savings in machining time of the order of 90 per cent are claimed.

The setting-up and changing of tools is done in a very simple fashion. As shown above, the body of the support is a box section. The tool is cradled in this box, where it is supported to within a fraction of the cutting edge by a stack of segments (shown more clearly below). The rigidity of the assembly is increased by the two bridge pieces which span the top and which also carry the clamping screws. Other screws apply lateral pressure to the segments which are all identical in height and length, but are made in four standard thicknesses. The required profile is drawn on graph paper and suitable segments sketched in to within 3mm or 4mm of this outline. From this diagram a simple template is made from wood or metal, with colours to indicate the segment thicknesses required. With the help of this template suitable segments can quickly be selected and correctly inserted in the support. The tool is then placed on top and clamped down. If required, further turning or parting tools can be clamped at either side of the box. The gauge shown on the first illustration serves to measure the depth of cut.



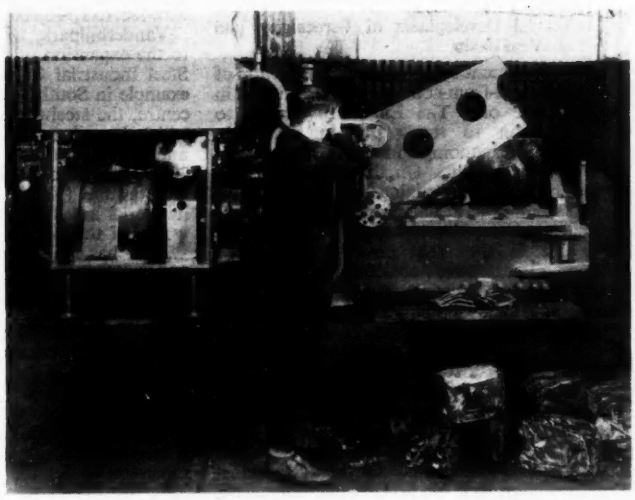
Support with bridge pieces and tool removed, showing supporting segments. This design permits the use of one additional turning or parting tool at the side of the box

Scrap Baling Press

THE illustration below shows a small hydraulically-operated scrap baling press which has recently been added to the range of heavy machines of this kind made by Fielding and Platt, Ltd., of Gloucester. The machine has a box 12in square by 36in long and, depending upon the material and loading, it produces bales weighing up to 1 cwt.

The baler is completely self contained with an 8 h.p. motor driving a two-stage radial pump delivering 2½ g.p.m. at a pressure of about 4500 lb per square inch. The main frame or box of the press is of welded steel plate construction and is lined with renewable wearing plates. Its cover, which effects initial compression of the scrap, is actuated by a hydraulic cylinder. Hard-faced shearing strips are fitted round the top edges of the box and the cover to cut off residual scrap when the box is closed.

Final compression of the scrap is effected by the driving forward of an alloy cast iron pressing platen by a horizontal hydraulic cylinder at the back of the box. A door which forms the front end of the box is swung open for the ejection of the bale. The makers state that the machine can produce up to forty bales an hour, depending upon the loading conditions.



Hydraulically operated scrap metal baling press

Improved Copying Technique for Drawings

SINCE the dyeline process was introduced some thirty years ago, many improvements have been made, but the successful production of a print has always depended to a very great extent upon the quality of the original. In recent years the speed at which drawings are required often makes it necessary to use tracings made in pencil on papers of various degrees of transparency. Frequently, in such originals, the contrast between the pencil line and the background is very poor and the production of a good print is difficult, if not impossible.

For this reason, Hall Harding, Ltd., Stourton House, Dacre Street, London, S.W.1, has introduced a new technique in coating for its "Unax" semi-dry dyeline papers and "Ammonax" ammonia vapour developed materials. With this technique it is claimed the density of line can be increased without need for reducing the printing speed, weak pencil lines are reproduced continuous and unbroken, lines are sharper and better defined and subsequent additions can be made in ink to prints without "feathering." In addition to these improvements for the above-mentioned processes, the firm informs us that it is also producing black line materials giving a much greater printing speed of equivalent line density than hitherto with speedier and easier development.

Institution of Production Engineers

ON Thursday of last week the new headquarters of the Institution of Production Engineers at 10, Chesterfield Street, London, W.1, were officially opened. It was intended that Sir Leonard Lord, president-elect of the Institution should perform the ceremony. He was, however, indisposed; and in his unavoidable absence Sir Walter Puckey, the president, after reading a message from Sir Leonard and after some reference to the history of the Institution, declared the building open.

The Institution of Production Engineers is now nearly thirty-four years old, having been founded on February 21, 1921. For several years thereafter there was neither a regular office nor a permanent staff. Not until 1929 was the need felt for a head office; and at that time a single room was acquired and a full-time official, Mr. Richard Hazleton, became general secretary. Within six years of that date membership had increased from 250 to 1200 and a small suite of offices at British Industries House, Oxford Street, housed the staff. In 1938 expansion in the number of members and their activities made offices of a more permanent character necessary and through the generosity of Lord Nuffield, the lease of 36, Portman Square, London, W.1, was acquired. Accommodation for meetings of the Council and committees thus became available and a library was established. But ill-luck befell it. In 1944 the premises were badly damaged by enemy action; and temporary accommodation had to be found until such time as reconstruction could be undertaken. Such, however, was the rapidity in the expansion of membership during and after the war—it reached 7300 in 1948 and is now over 10,000—that by the date when the premises could again be occupied it was already obvious that a more commodious building would be needed. This was found at the new headquarters at 10, Chesterfield Street, opened last week, the freehold of which has been acquired.

The large house which has now become the headquarters of the Institution was built in 1760 and is not only in excellent preservation but is an excellent example of its period. There are many period features including work attributed to Robert Adam. Paintings on the ceiling of the council chamber are believed to have been executed by Angelica Kauffman. Much work has had to be done to restore dilapidations and to furnish the building. The architect for this work was Mr. C. H. Brightiff. Lady Sempill gave much valuable help and advice in the decoration and furnishing of the entrance hall and public rooms. The Institution now has a headquarters that accords with its dignity and which should provide for the further expansion of its activities likely to follow from the continuing increase in its membership.

Book of Reference

Fork-Lift Trucking. Coventry Climax Engines, Ltd., Widdrington Road Works, Coventry. Price 5s. 6d. —This is a particularly comprehensive book for fork-lift truck users and states clearly the fundamental operating techniques, preventative maintenance practice, and safety rules which should be observed by truck operators. The notes are well illustrated and the points on essential safety measures which should be observed are specially emphasised. In preparing the book Coventry Climax Engines, Ltd., has obviously drawn upon extensive experience in the design and manufacture of fork-lift trucks, and the opportunities its representatives have had in observing their use in industry. Mechanical handling engineers will find this book a useful work of reference.

Indian Engineering News

(By Our Indian Correspondent)

Sui Gas Project in Pakistan

For some time now it has been apparent to everybody that Pakistan, and particularly its western wing, is a fuel-starved country. The annual consumption of coal is 1,600,000 tons, of which 560,000 tons have to be imported. The annual consumption of furnace oil is 605,000 tons, of which only 75,000 tons can be procured at home. The discovery of a big natural gas reservoir at Sui in Baluchistan has therefore been hailed as the most important event in the economic history of the country. The quantity has been estimated to provide Pakistan with equivalent alternative fuel to cover all these imports for the next sixty years. The natural gas reservoir, which was discovered by the Pakistan Petroleum, Ltd., in 1952, is thus expected to change the whole picture of Pakistan's natural development and is expected not only to relieve the country of much of the burden of its fuel imports but also to stimulate its further industrialisation.

The Sui structure is part of the Bugti hills of Baluchistan. About 50 miles north of the Sukkur Barrage an abrupt change from green, irrigated fields to barren sand marks the southern border of Baluchistan. A few miles further north the Bugti hills begin to rise out of the sands and it is here, on the first of the hill ranges, rising to about 850ft, that Sui is located. The testing of Sui formed part of a comprehensive prospecting programme planned immediately after partition and now being carried out by Pakistan Petroleum, Ltd. Acting on the reports of the company's petrologists and palæontologists, a start was made on the drilling of No. 1 well in July, 1951. Nothing striking was found until 3840ft, at which depth limestone was encountered. Brief tests during drilling showed that it contained gas. The well was continued down to a depth of 10,049ft without finding any other productive horizons. Sustained production tests were then made of the gas-bearing limestone. These confirmed that a large reservoir of natural gas has been found capable of yielding many millions of cubic feet of gas per day. A No. 2 well was immediately drilled on a location 5 miles to the west of No. 1. It also found gas in the same limestone, showing that the gas pool is at least 5 miles in extent.

The extent of the limestone is so far known only over the 5-mile stretch between wells Nos. 1 and 2. The gas is under high pressure and in this part of the pool alone geologists calculate that there are nearly 3 billion cubic feet of recoverable gas. This should suffice to provide 100 million cubic feet per day for eighty years. In fact, the quantity of gas there may well be two or three times as great as this initial estimate suggests. The gas is a dry gas consisting of nearly 90 per cent methane. The amount of gasoline, &c., which condenses from it is negligible. Such a great reserve of gas is more than enough to meet all the industrial needs of West Pakistan for generations to come.

The primary use of this natural gas will be as a fuel for stationary heat and steam power installations. It burns clearly and evenly and requires the simplest equipment for burning. It has a high calorific value, and can be transported in large volumes over long distances through pipelines. It requires no storage equipment on the part of the consumer and can be fed direct into the plant. The fact that it leaves no residue behind involving complicated disposal mechanisms is expected to make it an ideal fuel for such industries as cement, of which Pakistan is in short supply. The gas is also in itself an important raw material from which other products can be easily made. It will play an important role in the manufacture of nitrogenous fertilisers such as ammonium sulphate and ammonium nitrate. The gas can also be made to function both as fuel and raw material at the same time and to produce such items as alcohols, acids, fatty acids and aldehydes, which are useful in the textile, plastic and other industries. It is expected that Sui gas will play its part in all these processes.

The main demand at present lies to the south of Sui, and a pipeline is to be laid to serve this area. The route of the pipeline will be Sui-Sukkur-Rohri-Hyderabad-Karachi. Along this route, fuel requirements are estimated at nearly 50,000,000 cubic feet per day for plants already installed or definitely scheduled by the Central Engineering Authority and the Pakistan Industrial Development Corporation for completion by the end of 1955. Further prospects scheduled for completion within the next ten years will raise the demand in the area served by this pipeline to over 100 million cubic feet per day. The plants earmarked to take the gas include gas turbine and steam power plants, cement plants, and spinning mills.

The Sui-Karachi pipeline is to be 16in in diameter and will be 350 miles in length. It has been so designed that the gas will be self-propelling from Sui to Karachi when transmitting volumes up to 7,000,000 cubic feet per day. When the requirements exceed this quantity, compressor plants will be installed to enable the pipeline to transmit gas at its designed capacity of some 100 million cubic feet per day. The cost of the initial installation, together with all plant and machinery required for delivery of up to 70,000,000 cubic feet per day is estimated at approximately Rs.8·4 crores (£6·3 million). To increase the throughput to 100 million cubic feet per day, an additional Rs.1 crore is expected to be required. Work on the construction of the pipeline is proceeding apace and it should be complete within the next two or three years.

African Engineering News

(By Our South African Correspondent)

Industrial Development of Vereeniging and the Vaal Basin

The recent opening of the first section of the "Sasol" oil-from-coal project mentioned in the last issue of "The Engineer" serves to draw attention to the many enterprises in the rapidly expanding industrial region of the Vaal River basin. On the Transvaal bank of the river is Vereeniging, the original industrial centre, and Vanderbijlpark, the scene of great post-war development. On the Free State side is the Vaal power station. The presence of extensive coalfields, an assured supply of water, electricity from modern power stations and the availability of cheap land, have all contributed to the development of this area.

The proximity of Vereeniging to the Free State goldfields, the Witwatersrand and to other developing industrial areas, leaves little doubt that it will become a major manufacturing centre. The town planning scheme envisages a total population, ultimately, of 350,000, of which 100,000 will be Europeans. Of the older industries, the Union Steel Corporation has influenced the character of new undertakings, with the result that Vereeniging is to-day essentially a "steel" town. The ingot steel capacity of Usco is approximately 115,000 tons per year and the annual capacity of its copper plant is 20,000 tons. Other old-established industries are the African Metals Corporation Ltd. (Amcor), Stewarts and Lloyds, Ltd., Vereeniging Brick and Tile Company, African Cables, Ltd., and the South African Farm Implements Manufacturers (Safim). When the new Kookfontein works of Amcor have been completed later in the year, they will compare favourably with the most modern ferro-alloy plants in the world. Last year Amcor produced over 30,000 tons of various grades of ferro-alloys, much of this being for export. The newer industries include factories of Babcock and Wilcox of Africa, Ltd., Raleigh Industries of South Africa, Ltd., Irvine and Chapman (Pty.), Ltd., and African Disc Company (Pty.), Ltd.

The Vereeniging and Witbank power stations transmit power by high-voltage transmission lines over the licensed area of supply of the Rand undertaking to the Witwatersrand and outwards to Springs and Nigel, to Mafeking in the west and north, to Rustenburg and Thabazimbi. From Vereeniging there are also transmission lines running westwards to Potchefstroom and Klerksdorp, and south to the new Free State goldfields. The Vereeniging power station, first of the power stations to be built in this area has an installed capacity of 157·5MW. The Klip power station has a total installed capacity of 424MW, ad the Vaal power station 172MW, which is now being increased to 318MW. Taaibos power station will be completed in 1957 and will deliver 420MW.

Coal is obtained from the Vereeniging coal area. The bulk of the coal is low-grade and is used mainly by the power stations. The reserves of coal of marketable quality in the area have been quoted as high as 10,318 million tons *in situ*, but the Coal Commission in 1948 gave a figure of 4000 million tons. The Klip power station is supplied with coal from the new section of the Springfield Colliery at Grootvlei. The other two collieries are across the river in the Orange Free State. Of these Cornelia colliery supplies the Vereeniging and Vaal power stations, while the Clydesdale colliery, which is at the extreme south of the coalfield, will supply the new Taaibos power station. Beyond the borders of the table coalfield is another area containing coal below the required standard. In normal circumstances it would not be worked, but the advent of "Sasol," the new oil-from-coal project at Coalbrook will enable these low-grade coal reserves to be usefully extracted.

As for water, the Rand Water Board supplies more than 90 m.g.d. to a population of 2¼ millions. The limits of supply cover 4300 square miles of the Southern Transvaal. Consumption estimates indicate that a supply of 130 m.g.d. will be required by 1955 and a new purification works has been built which will produce an additional 40 m.g.d. More water will be impounded when the present 162ft high wall of the Vaal dam is raised by a further 20ft, increasing the storage capacity of the dam from 873,000 acre-feet to 1,998,000 acre-feet.

Vanderbijlpark, which owes its establishment to the expansion of the South African Iron and Steel Industrial Corporation (Iscor), is the first example in South Africa of a planned industrial centre, the steelworks serving as a basis, round which have been built a number of secondary and light industries. The town now houses over 30,000 inhabitants. The Vanderbijl Engineering Corporation (Vecor) is also situated here, and its works are the largest integrated engineering works of their kind in Africa. The Iscor Steel Works has an ingot capacity of 320,000 to 350,000 tons per annum, and the plant is laid out so as to be readily capable of extension to an ultimate annual ingot capacity of 1,000,000 tons. By-products such as road tar, motor benzole, creosote, ammonia, coal tar solvents, naphthalene, &c., are also produced. Vecor, with its large foundry and machine shop, provides what was previously a marked deficiency—a heavy engineering works manufacturing the plant requirements of heavy industry. Mining requirements for the Free State Goldfields have been a valuable part of its production. Other important concerns in this area are Dorman Long, Metal Box Company, Boulton Paul, African Oxygen and Acetylene, and Acrow Engineering.

A new railway station has recently been opened at Vereeniging and a new marshalling yard is to be built near the town at a cost of £286,000. The line between Union and Vereeniging is to be doubled at an estimated cost of £1,235,000, and electrification of the line carried out from Midway to Vereeniging. A new road bridge will span the Vaal River to link the Golden Highway with Sasolburg, the industrial centre of "Sasol," and another is being built 4 miles downstream from Vereeniging connecting the national road from Johannesburg to Parys with the Sasolburg area.

Factory Expansion at Fort Elizabeth

General Motors (South African), Ltd., is spending £500,000 on extensions to its assembly and manufacturing plant at Port Elizabeth, the work to be completed by September of next year. The programme includes an increase of floor space by one-third and new machinery, such as presses for the manufacturing plant, where refrigerators, electric stoves, complete truck cabs, vehicle leaf springs, exhaust pipes, silencers and various other products are made. Equipment has also been installed in the factory's battery manufacturing plant during the past few months.

Pacific National Exhibition, Vancouver, British Columbia

(Contributed)

BRITISH COLUMBIA was witness to eleven days of industrial and commercial display at the forty-fourth Pacific National Exhibition, recently held in Vancouver, at the Exhibition Park.

It was regrettable to note that British industry did not support the western presentation to the extent that it supported the Toronto Exhibition, with examples of British manufacture. The fact that there was a complete display by German industries and an exhibit by the Japanese Consulate, would seem to indicate that more interest could be displayed in the West, where a very large percentage of United Kingdom industrial exports ultimately arrive. Besides, it is in this area that Canada's most rapid growth is now to be witnessed.

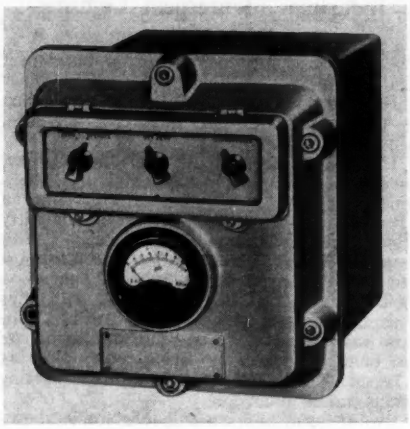
Only one exhibit was wholly of British equipment. This was a display put on by the company here that is acting as the manufacturer's agent. This exhibit was a well-presented display of industrial engines. However, it is felt that it would have been even more advantageous had a technical sales engineer, direct from the manufacturer, been present to answer detailed questions and study problems arising out of the workings of the exhibit, and the equipment on the field. In discussion with engineers attending this display, the opinion was expressed that much more could be done by sending out, from Great Britain, technical men capable of handling enquiries and complaints from engineers and other users, who are more versed in local conditions than those designing engineers in United Kingdom offices of different manufacturers that ship to the North American market. An oft-repeated complaint of users of British equipment is that in cases where technical men are sent out from the British head office, they fail to appreciate the local working conditions and the opinions of present users of the equipment.

In relation to diesel engines many expressed their strong desire to use the British products, in this line. But they wanted it made known that many aspects of the present designs exported to Canada do not fit in with heavy industrial usage. A new clutch system in marine diesels would, for example, be advantageous, as in some British manufactured diesels the clutching system is held not to come up to the standard of those manufactured in other countries. Another point is that although aluminium oil pans are satisfactory for some services, they are definitely not suitable for use in heavy logging, or land clearing operations, where a strong pressed steel pan is essential to protect the engine from log, stump or rock damage. Some British manufacturers are understood to be making modifications in fuel pump design. That is a change essential to meet local service conditions and competition from foreign manufacturers.

It was interesting to note the number of suppliers and contractors that were promoting items from Britain in their exhibits. But it seemed to be generally felt that many items so far not touched by manufacturers in the United Kingdom could be put into production and exported to British Columbia with advantage to the users in design, and in price. Amongst products mentioned were logging engineering equipment, sawmill machinery, automatic multiple action, speciality pipe-fitting machines, smaller units for central heating and radiation heating panels. Manufacturers of refrigeration equipment, particularly units that can be operated on various modes of power and fuel, might do well to investigate the Canadian market.

Interesting items to be found in several sections of the exhibition were glass panel heating units which provide radiant heat, with central heating control. They combine convenience with ease of installation and clean use. The panels are of processed glass elements, within which electrical resistances are incorporated to provide infra-red radiation, so that heat is supplied to the contents of the heated rooms.

Many houses and offices are using this system for their heating installations and there are industrial possibilities that are being developed.

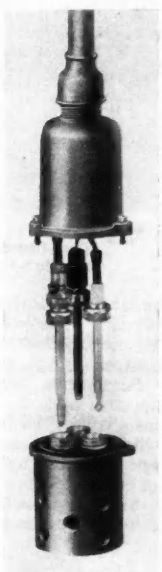


Industrial pH-amplifier in fireproof housing

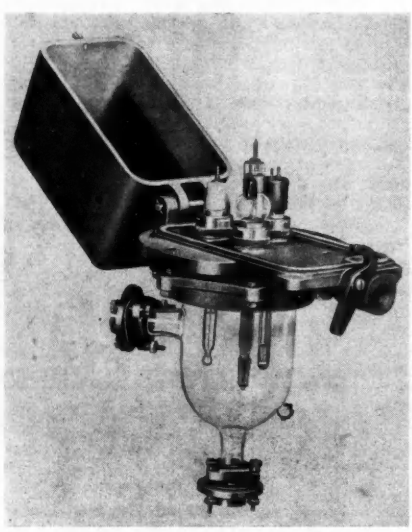
Industrial pH-Amplifier and Electrode Assemblies

AN industrial pH-amplifier with associated immersion and flow electrode assemblies has been developed by W. G. Pye and Co., Ltd., Granta Works, Newmarket Road, Cambridge. The accompanying illustrations show the unit and the two kinds of electrode. In order to enable the amplifier to be installed in oil refineries and similar locations, the instrument is housed in a robust flameproof case. Servicing on site is reduced to the simple operation of replacing the plug-in chassis. In addition automatic temperature compensation and mains stabilisation are provided.

The immersion electrode assembly consists of a watertight chamber through the base of which the glass and reference electrodes and the temperature compensator protrude into a perforated protector. The electrode can easily be removed for cleaning or replacement. Similar electrodes and compensators are fitted to the continuous-flow assembly, but here they are enclosed beneath their mounting plate in a " Pyrex " glass flow chamber. This is resistant to a very large number of chemicals and can quickly be replaced.



Immersion electrode assembly



Flow electrode assembly with electrodes and compensator mounted inside glass flow chamber

The behaviour of proposed control systems can be predicted by means of a process simulator which the firm has set up. It consists of a closed circuit which can easily be modified to suit requirements, but which in its simplest form comprises a reaction tank, circulating pump and delay line. Electrodes can be inserted at a number of points and transmit their readings to the amplifier. An automatic control and recording system maintains the required pH value by adding reagents from separate tanks and records the result.

Works Extensions

THE second stage of development at the South Works of the Power-Gas Corporation, Ltd., and Ashmore, Benson, Pease and Co., of Stockton-on-Tees, has just been completed. The first stage of development was completed in 1951, and in this second stage two transverse bays 85ft wide and 250ft long have been added to the constructional shops. Each bay has a 10-ton and a 20-ton crane, the crane tracks being 30ft above floor level. Two longitudinal 65ft wide bays, which were originally 342ft long, have also been extended to a length of 170ft. As a result of the extensions the floor area has been increased by 50 per cent to 215,600 square feet and the assembly area available has been more than doubled.

In connection with the extensions new manipulating equipment has been installed to deal with the many classes of work undertaken in mild steel, stainless steel, nickel, nickel clad steel, " Inconel," " Monel," &c.

The new machine shop is 250ft long and 112ft wide, or 130ft wide if the annexe is included, and provision has been made for its extension to a length of 700ft. This shop has been equipped with a selection of heavy machining plant and the handling facilities include a 50-ton electric travelling crane with a 10-ton auxiliary hoist and a 15-ton crane is also to be erected. To cope with the increased quantities of materials required in the new extensions the length of the stockyard gantry has been extended from 400ft to 800ft and a new 10-ton crane has been installed.

Diffused Lighting System

A NEW architectural lighting system has been announced by Lumenated Ceilings, Ltd., 4, Lloyd's Avenue, London, E.C.3, a subsidiary of Thermotank, Ltd. It consists of a ceiling of corrugated translucent vinyl sheet which is supported in a framework of lightweight steel, below fluorescent or tungsten lamps. The plastic sheeting diffuses the light to form a luminous ceiling, without glare, or shadow ; the intensity of lighting can range from 20 to 200 lumens per square foot, it is stated. " Lumenated " ceilings, as they are called, are claimed to be a near approach to natural daylight and are intended for use particularly where a large area has to be illuminated. Fluorescent lamps are generally the most satisfactory light source for this ceiling, it is stated and, except where excessive plenum depths are encountered, the use of separate reflectors behind the lamps is not necessary.

FOUNDRY APPRENTICES' COMPETITION.—The London branch of the Institute of British Foundrymen is organising an apprentices' competition. It is to be a test of practical foundry skills, i.e. ability to plan methods of moulding, coremaking, running and risering of a casting and then producing that casting in the metal of the competitor's choice. Each competitor is to be supplied with an identical set of pattern equipment for the purpose and his employer's help will be enlisted to exercise supervision and control. The competition is open to all apprentices residing in or working in the area served by the London branch and its four sections (East Anglia, Slough, Southampton and Beds and Herts) and who were below the age of twenty-one on September 30, 1954. They must be serving a recognised course of foundry training, and age will be taken into account when assessing the castings produced. The closing date for receipt of entries being November 30, 1954. Intending competitors should apply to the Organising Secretary, Mr. A. R. Parkes, *Foundry Trade Journal*, John Adam House, Adelphi, London, W.C.2 (telephone. TRAfalgar 6171).

Hand-Operated Thrust Borer

A NEW manually-operated "Skylux" thrust borer for use in installing underground pipes and cables has been introduced by S.L.X., Ltd., Brunel Road, London, W.3. This machine can be used in any soil which can be dug with a spade and is stated to be capable of driving a hole under a 30ft wide roadway in about two hours. It is designed to exert up to 12 tons thrust and its general construction can be seen in the photograph we reproduce below.

The main frame of the machine consists essentially of two heavy end plates coupled together by four tie-bars, and supporting in thrust bearings two thrust screws. The substantial threads on these thrust screws are machined right-hand at one end and left-hand at the other.

A fixed head is bolted rigidly to the tie-bars in the centre of the machine, and a worm shaft in the lower part of the head turns worm wheels keyed to the thrust screws. Hexagon ends on the worm shaft take the ratchet levers used to operate the machine. A travelling crosshead guided by the tie-bars and coupled through nuts to the thrust screws is mounted on each side of the fixed central head. As the thrust screws are turned they move the travelling crossheads in unison in opposite directions towards or away from the centre of the machine.

Each end plate has on it a socket and by mounting sighting poles in these sockets, which are on the centre line of the machine, the required line of the bore can be set. A gradient sighting level can be also used with the machine to set the required inclination of a bore.

Hand-lever-operated thrust borer with pilot tube in position ready to drive initial bore. The equipment is designed to exert up to 12 tons thrust

When using the machine it is set in a pit in the usual way, and a receiving pit is dug where the end of the bore is to come out.

In the first operation the special pilot tube is attached to the travelling crosshead at the back of the machine by means of a thrust collar, and the front of the tube is supported in alignment by a guide collar in the front plate. Operation of the ratchet hand levers draws the crosshead along to drive the tube forwards until the head reaches the centre of the machine. The thrust plate is then inserted in the front crosshead which has been drawn back to the centre of the machine as the rear crosshead moved forwards. The pawls of the operating levers are then reversed, and as the levers are then worked the front crosshead continues driving the tube forwards.

At the conclusion of the pilot tube driving movement a standard 3ft thrust tube is screwed on its end and connected through the thrust collar to the rear crosshead of the machine for the driving cycle to be continued on reversal of the lever pawls. By means of a thrust plate the tubes can be withdrawn from the bore and, after the 3in diameter pilot bore has been made, enlarging heads can be pulled back to increase the diameter of the bore.

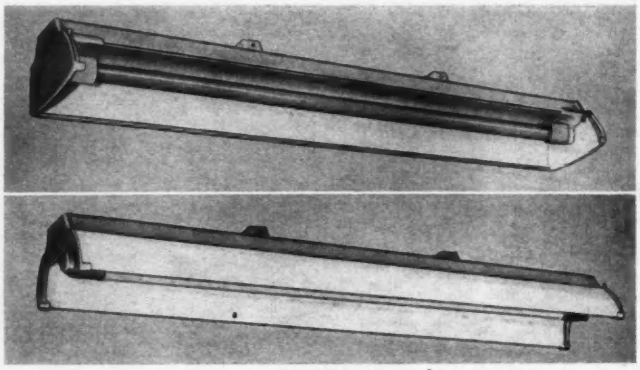
A battery-operated lamp fitted in the pilot tube head can be used in conjunction with the gradient sighting level to facilitate checking that a bore is maintaining the predetermined level and direction.

Industrial Fluorescent Lighting Fittings

A RANGE of fifty-four industrial fluorescent lighting fittings consisting of various combinations of ten component parts has been developed by Crompton Parkinson, Ltd., Crown House, Aldwych, London, W.C.2.

The basic components for this range are one-lamp and a two-lamp general lighting fittings which can have base reflectors with either a "Permawhite" stove enamel finish or, for gritty atmospheres, a vitreous enamel finish. With these two general lighting fittings the full range can be built up by the addition of light alloy die-cast end plates which are fitted with clips whereby the side reflectors are attached. In this way open—or closed—top assemblies can be built up and, by using opal diffusing "Perspex" side reflectors, translucent lighting effects can be obtained.

By dispensing with one side reflector, as shown in the upper illustration, the fittings become suitable for display lighting. With the full complement of reflectors or a single-side reflector, all the closed-end fittings can be converted to louvre fittings simply by attaching a rigid "Permawhite"-finish metal louvre having approximately 25 deg. to 35 deg. cut-off. For installations where economy is paramount and where louvres are not likely to be required, open-end reflector supports can be fitted, instead of end plates, as shown in the lower illustration.



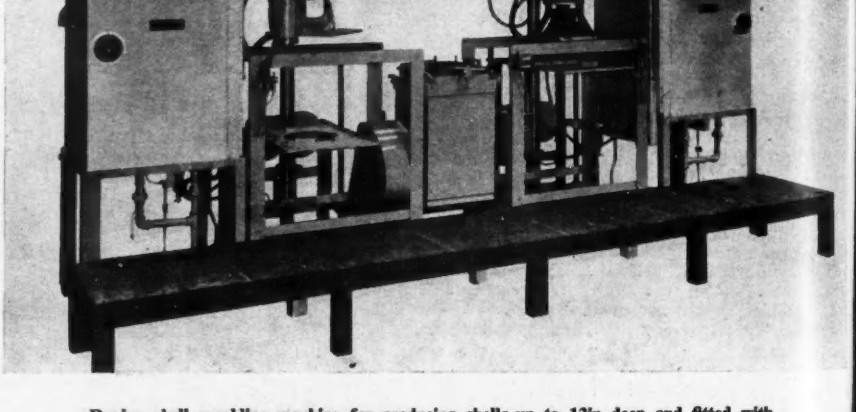
Top—fluorescent lamp fittings assembled for display lighting with a single reflector. Below—open ended fluorescent lighting fitting

Simplicity of installation and maintenance characterises the design of these fittings : built-in quick-fixing devices are provided for close ceiling mounting, and infinitely variable fixing centres are incorporated for ceiling or pendant mounting. To simplify lamp replacement the lamp is carried at each end in a spring-loaded, compensated contact holder with a sliding end shield. The lamp caps are earthed at both ends. Reflectors can be removed for cleaning without the use of hand tools and while the lamp is switched on. Similarly, the louvres are fitted and removed without screws or other accessories.

Deep Shell Mould Making Machine

PARTICULARS have been received from Fairbairn Lawson Combe Barbour, Ltd., Leeds, of a shell moulding machine which can be used for the production of shell moulds from patterns up to 13in high. This machine takes pattern plates up to 16in square and, as can be seen from the illustration at the foot of this page, has a central dump box with a pattern preparation and curing oven unit on each side. On it the normal shell mould making procedure is followed, using one unit for pattern preparation and investment whilst in the oven of the other the mould is being cured.

As particularly deep moulds are produced a special ejection equipment has been fitted on the pattern stripping and preparation slides. When the pattern plate is removed from the oven it is suspended from the slides with the cured mould facing downwards. An ejector plate mounted on a column at the rear is then swung round by hand to register over the pattern. As this plate is moved over the pattern plate a mould receiving plate in the lower part of the frame is automatically raised to its effective position beneath the mould. Depression of a handle on the ejector plate then operates the ejector pins to thrust the mould off the pattern. The mould is caught and retained in the receiving plate and as the ejector is swung back on its column the receiving plate is lowered in the frame. The receiving plate can then be pulled out along its guides for the removal of the shell mould.



Duplex shell moulding machine for producing shells up to 13in deep and fitted with automatic receiving equipment for mould ejection

Canadian Engineering News

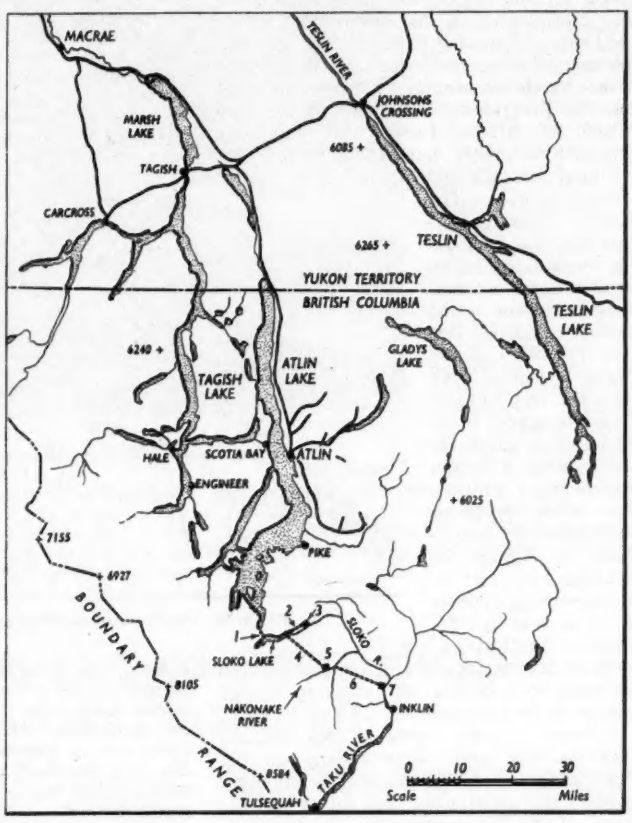
(By our Canadian Correspondent)

Earl H. Eacker, president, American Gas Association and Boston Consolidated Gas Company, speaking recently at the Pacific Coast Gas Association Convention at Vancouver, commended the developments of the gas utilities in the Pacific Northwest, and their modern research methods. He stressed the development of equipment design on a more advanced basis, with even greater safety factors. After mentioning refrigeration by gas, he went on to state: "One of the most fertile fields to-day is the gas air-conditioning field. Its importance to us for the future and its possibilities are so great, I call it especially to your attention. Particularly do I believe we should step up on research on this. . . ." He stressed the fact that the Pacific Northwest would be one of the territories into which natural gas would be brought, this coming at a time when the engineering of the Peace River natural gas pipeline has been temporarily halted, due to the American refusal to grant the permit for entrance of the pipeline into the American states of Washington and Oregon.

According to Mr. Hargreaves, gas engineer for the B.C. Electric Company, the Canadian utility company behind the Canadian-American pipeline, the return on the Canadian Western cities usage, of natural gas, would not warrant, at present, the construction of line, which called for 24in pipe from the Peace River district to Chilliwack, and Vancouver, and 20in lines to points south of the International Border, with ten booster stations for 950 lb W.P. service over the mountainous terrain, giving a total length of nearly 1700 miles. A revised proposal will be put before the American Power Commission at a later date.

* * *

On the British Columbia–Yukon border, the construction of a great hydro-electric project centred around Taku Inlet, near the Alaska border, is about to be begun. It is estimated to be capable of producing more than twice the power potential of the Eastern Canadian St. Lawrence seaway power developments. The project will draw water from the Yukon river, and bring in White Horse, Teslin Lake, and the Taku river, in a dam and tunnel project which will form a lake system that will rank second to the Great Lakes in water area in all North America. Initial drawings show a 1 mile tunnel from Atlin to Sloko Lake, and a 2·1 mile tunnel from Sloko Lake to Sloko river construction plant, generating 24,000 h.p. Another tunnel (9·7 miles) runs from Sloko Lake to the penstocks, and power-house (2,800,000 h.p.) on the Nakonake river, and yet another (8 miles long) carries the water from the Nakonake to the 1,500,000 h.p. power-house and penstocks on the Taku river. A further 560,000 h.p. is open for future development on the lower reaches of the Taku river. The area covered by the project amounts to 60,000 square miles, and the scheme is the result of a two-year survey made by Frobisher, Ltd., during which time that firm was recommended to increase the initial plan by the British Columbia Government, which considered the original plan too small in relation to the power potential. As it now stands, the first start on this project, which will reverse the flow of the upper Yukon river, will be begun, of necessity, under the British Columbia Government agreement before October 1, 1955, when the construction of the 24,000 h.p. power plant must get under way.



1—Tunnel, 1 mile long
2—Tunnel, 2·1 miles long
3—Sloko construction plant
4—Tunnel, 9·7 miles long
5—Nakonake penstocks and power house
6—Tunnel, 8 miles long
7—Taku penstocks and power house

Area of proposed hydro-electric power project for Frobisher Smelters and Metal Industries

* * *

From Victoria, B.C., Railways Minister, Ralph Chetwynd has announced that the laying of the first track of the Vancouver Squamish link of the Pacific Great Eastern Railway will be made in December or January. The first section will be in North Vancouver. Next spring, starting in the opposite direction, the track laying from Squamish to Britannia should begin. The Emil Anderson Construction Company hopes to make a start on the 1600ft tunnel, north of Fury Creek, by next month.

* * *

Canadian National Railways are laying 10 miles of continuously welded rails east of Belleville, Ontario. This section of track is intended to be a test to see whether the continuously welded rails of this type and method of laying will stand up to the rigorous Eastern Canadian climate. The process of laying differs from that of the regular track. Each section consists of 1200ft of rail, composed of 40ft sections, welded together. After laying the 1200ft sections, they are, in turn, welded into the continuous lengths. The purpose of laying the track is to study the effects that the severe extremes of winter and summer temperatures will have on this stretch of track. If there is no buckling, due to the expansion and contraction, many thousands of miles of Canada's railroad systems may eventually become a wholly continuous-weld permanent way. Advantages of the system under test are smoother riding for passengers and freight, with a saving, in maintenance costs, of up to 15 per cent. With the present modernisation of the rolling stock, by both Canadian Pacific and Canadian National Railways, which includes new stainless steel sleeper, coach and dome-observation cars, on the Trans-Continental routes, and the rapid swing over to the diesel and diesel-electric locomotives, the engineers of the companies are endeavouring to produce a road bed and rail system that will meet the improved equipment.

* * *

The President of a newly formed company, British Columbia Engineering Company, Ltd., Mr. Thomas Ingledow, stated recently that it is a group of skilled and experienced consulting engineers working in conjunction with the parent company, B.C. Electric Company, which is, itself, one of the major transport, power and gas corporations of North America. He expects the new company to be in a satisfactory position to undertake all phases of electrical, mechanical and industrial engineering, both for its parent organisation and for outside contracts.

* * *

It has been announced that a new engineering firm has been formed in Toronto. An affiliation of the Dravo Corporation of the United States, the new company, Dravo of Canada, Ltd., will act as engineers, contractors and builders across Canada, covering such work as the construction of dock and bridge substructures, intakes and pumping houses, tunnels, locks, dams and deep shafts and foundations.

With the formation of the company, K. C. Cox receives the appointment of chief engineer for the whole of the Canadian group, with head offices in the Commerce and Transportation Building, Bay Street, Toronto.

* * *

The Powell River Company has appointed W. J. G. Kennedy as field engineer for the construction of its new Martin paper carton plant, on Lulu Island, British Columbia. Mr. Norman Walton has been appointed chief industrial engineer of the company's engineering department, with Leonard A. Murphy, design engineer, named as his assistant. Both Mr. Walton and Mr. Murphy are University of British Columbia graduates. Mr. Walton joined the company in 1949, and Mr. Murphy worked at Powell River as an undergraduate, under the university students' training programme, operated by the company.

* * *

The Aluminum Company of Canada has announced that the new pot line at Kitimat went into operation on September 20th. It also announced that there is to be a 45,000,000 dollar expansion programme at Kitimat, with the installation of one more generating unit, already on order, and two more pot lines. This will boost aluminium production by 60,000 tons per year, over and above the present 91,500 tons.

* * *

The British Columbia Government has put forth a proposal for a toll super-highway, between Vancouver and the United States. It would include two high-level, multiple-lane bridges.

* * *

A Ford engine factory is to be built in the Vancouver industrial area. It will be for the remanufacturing of Ford engines that hitherto have had to be sent back to the Eastern factories. The plant is to be located in a former car storage building, the precision machinery being ordered from Eastern Canada.

* * *

It is reported from Montreal that the Canadian National Railways have ordered 127 new diesel locomotives, from five leading North American locomotive manufacturers.

* * *

Wire rope manufacturing equipment is on order from England for the new 1,000,000 dollar Vancouver plant for Wrights' Canadian Ropes, Ltd. McCarter, Nairne and Partners were architects for the project.

The American Scene

(By Our American Editor)

ATOMS FOR PEACE

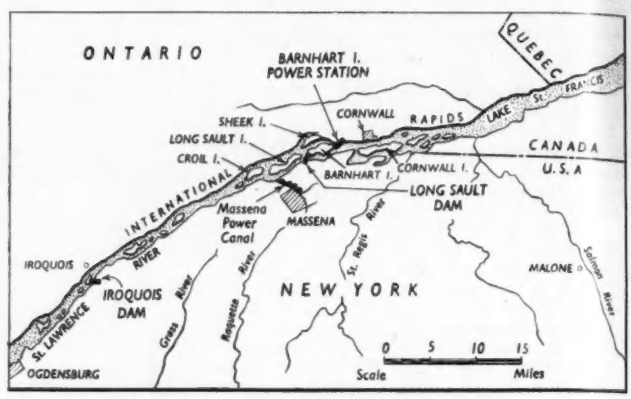
Two events of great significance to the peaceful development of atomic energy occurred in the United States in September of this year. In a doubly symbolic action on September 6th, President Eisenhower waved a radioactive wand in Denver to break historic ground in two fields in order to turn the unleashed genie of atomic power from purely destructive purposes to become a mighty and tireless servant and benefactor of mankind. He transmitted the electric signal which started work at Shippingport, Pennsylvania, on America's first commercial atomic power plant. At the same time he announced that, despite Soviet recalcitrance, the United States had just agreed with a number of other nations to go ahead with the development of the international atomic pool for peaceful purposes that is to make possible the construction of such power plants all over the world, as proposed in his speech before the United Nations last December. Americans realise that the Shippingport plant is not the first atomic power station to be started. One such plant is already under construction in Cumberland and another one has been started in France. But these plants are still mainly experimental and Government-owned. The Shippingport plant will not only be the largest of those now planned, but also the first private and commercial plant of the kind, designed, in the President's words, to advance the economic production of atomic power and thereby bring mankind closer to the fulfilment of the ancient dream of a new and better world. The importance of such a development cannot be measured merely by the price of atomic power, which at the start may well be higher than that of power from present sources. Rather it will have to be measured by two other more important factors. One of these factors is that in an age of rapidly rising power consumption the conventional sources of such power are limited, and that some nations, including Britain, face a definite shortage in such sources within a decade. The second, even more significant, factor is that the commercial development of atomic power for peaceful purposes is also one of the best available weapons of the free world. It is bound to exert pressure on Soviet Russia to break the disarmament deadlock which now threatens mankind with an atomic war in which, according to some scientists, the explosion of a few thousand large atomic bombs would so poison the atmosphere with radioactivity as to wipe out human life on earth.

The major policy address before the United Nations of the American Secretary of State, Mr. John Foster Dulles, on September 23rd, constitutes the second important development aimed at a peaceful use of atomic energy. Documents, which recently were jointly released by the United States and the Soviet Union, make it clear that from the day when the first atomic bomb was exploded in New Mexico, the United States realised the heavy social responsibility that it had incurred. Singly and with the United Nations it framed plan after plan for the orderly utilisation of atomic energy under international control. The plans came to nothing because of Russian refusal to accept the one kind of international control that would ensure peace and security. Despite these failures the Americans have never given up the hope that their conception will prevail and, in his appearance before the General Assembly of the United Nations, Secretary Dulles reaffirmed this determination. Much has already been done to carry out the programme outlined. In the first place, the Atomic Energy Act has been amended to remove many obstacles to international research and development. The United States is negotiating with Belgium for the building of an atomic power reactor. Atomic power is the subject of current discussions with Canada. Soon America will have the very kind of "reactor school" that Mr. Dulles wants for the training of foreign engineering students. An often-proposed international conference to discuss the whole subject of atomic energy in peace is to be held in 1955. Finally, medical and surgical experts are to meet and consider the immense possibilities of applying atomic energy in the treatment of cancer.

It must not be supposed that because America has spent more money on the development of atomic energy than any other country this programme calls on its part for more giving than receiving. On the contrary, American scientists realise that they have much to learn from Europe. Britain has gone far in the development of atomic power—farther, perhaps, than the United States, at present. Medical men on the Continent can tell Americans of successes and failures with the fundamental particles that play their part in the transmutation of uranium. Indeed, so alluring are the prospects of such a co-operative effort that it is hard to see how Russia can afford to isolate herself. It may be that the Russians think so themselves, since Mr. Vishinsky was willing to have Mr. Dulles's programme laid before the General Assembly of the United Nations for discussion. But since prolonged discussion is a favourite Russian tactic for postponing action indefinitely it does not follow that Mr. Vishinsky will not insist on atomic disarmament as an unacceptable condition precedent to Russian participation in the proposed atomic power pool, as he has insisted in the past.

St. Lawrence Power Project

On August 10th, dual celebrations were held on American and Canadian soil to inaugurate the 1900MW hydro-electric development whose power will be shared equally by the two nations and which will be constructed jointly by the New York State Power Authority and the Hydro-Electric Commission of Ontario. The ground-breaking festivities began on the American side of the border near Massena, New York. Governor Dewey pressed a button setting off dynamite blasts off Barnhart Island, where one of the dams will be built. Then the ground-breaking party travelled to a point near Cornwall, Ontario, where Prime Minister St. Laurent removed the first spadeful of earth at the Canadian power station site. As indicated in the accompanying map, the St. Lawrence hydro-electric development will consist of two major dams, the power station structure, power generating and transforming facilities, extensive channel works and dykes and wing dams. The dams will be known as Iroquois dam, a short distance downstream from Ogdensburg, New York, and the Long Sault dam, near the head of Barnhart Island. All power will be generated at the Barnhart Island power plant with one end of the station being in the United States and the other end in Canada. The construction of the two cofferdams is expected to begin immediately. The first generation of power is scheduled to begin in 1958 and the project is expected to be completed a year later. The cost of the scheme will be shared equally by the two power agencies, excepting machinery and equipment for the respective power plants. The St. Lawrence Seaway project and the hydro-electric power project are closely related, but financially and otherwise separable. The two schemes will be constructed by different contracting groups. The joint use of the river by the two projects, however, requires that they be completely co-ordinated in planning and operation.



Map of St. Lawrence hydro-electric power project

One-Cubic-Yard Shovel-Crane with Hydraulic Controls

The Link-Belt Speeder Corporation, of Cedar Rapids, Iowa, is now producing a 1-cubic-yard shovel-crane which has been designed to bridge the gap between the application and portability advantages of machines up to ¾ cubic yard and the output advantages of the larger, heavier units. With regard to transportability, the crawler-mounted "LS–98," when equipped as a shovel, weighs approximately 53,000 lb. Therefore, it can be loaded on a flat bed trailer and legally hauled in most American states without major disassembly. The hydraulic system of the unit employs a Vickers hydraulic pump which supplies fluid under pressure to an accumulator and the control valves in the cab. Short-throw levers mounted at a height convenient to the operator are used to actuate the valves and thus control the fluid flow to clutches and brakes. The valve settings are infinitely variable within the operating range to ensure smooth operation and to let the operator "feel" the load. According to the manufacturer, the hydraulic system can boost production 25 per cent due to the minimising of operator fatigue.

The shovel-crane employs an all-welded box section structure with 12in heavy ship channel main members. The undercarriage mounting employs four rotating hook rollers in the front and two in the rear. The front rollers are set in equalised pairs to spread the maximum loads.

Crawler-mounted " LS-98 " shovel-crane

clutch assembly can be completely removed without dismantling a single section of the cab. All of the clutches are interchangeable and easy to operate. The clutch and brake for each track are interconnected so that the brake is automatically applied before the multi-jawed clutch is disengaged. Steering is controlled by two short-throw levers at the operator's position. When equipped with a 40ft boom, the crane has a lifting capacity of 20 tons at a 10ft radius. The addition of a counterweight can increase this to 22·5 tons. The standard power unit for the shovel-crane is a Waukesha " 140 GK " six-cylinder petrol engine which is rated at 99 h.p. when running at 1600 r.p.m.

The side frames of the machinery unit are jig-bored after assembly to ensure a rigidly controlled alignment of the drum shafts. Each horizontal shaft can be removed for servicing independently of all others. Furthermore, each

Three-Hinged Arch Hangar at Pittsburgh

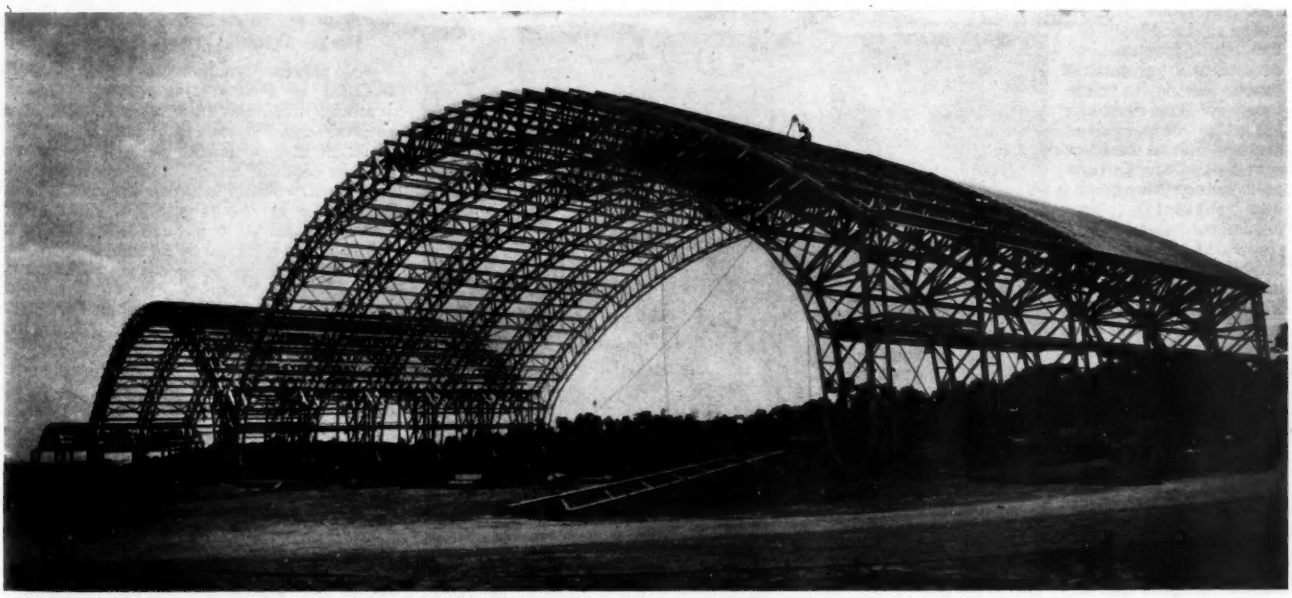
A MULTIPLE-SPAN hangar employing an unusual box-shaped, three-hinged trussed steel arch has now gone into service at the Greater Pittsburgh Airport in Allegheny County, Pennsylvania. With a clear span of 278ft, these arches are among the longest ever built in the United States utilising a three-hinged steel trussed arch design. The individual arches are spaced at a centre distance of 25ft. The arch section is composed of four chord angles arranged in a box section 4ft wide and varying in depth from 8ft to 14ft. The end arches are braced in pairs to obtain the required structural rigidity and to transmit the wind loads from the end walls of the hangar. Hinged connections are provided at each arch base and at the crown joint, which is situated at the centre line of the span A pair of tie rods at each arch, consisting of solid round rods placed under the hangar floor, are provided to transmit the arch thrust.

In the design of the arches three conditions of loading were considered : (1) a snow load of 30 lb per square foot on the entire span in addition to the structure dead load of 23 lb per square foot ; (2) a snow load of 30 lb per square foot over one-half of the span in addition to the full wind load and dead load ; (3) the wind load acting only in conjunction with the dead load. In combination with the wind loads, the snow load of 30 lb per square foot was considered to be acting only on the leeward half of the arch span. The wind pressures used in the design computations were in accordance with the recommendations of the American Society of Civil Engineers. Accordingly, for vertical surfaces projected to the wind, a wind pressure of 20 lb per square foot was used. For the rounded roof above the eaves the following wind pressures were used :—(1) Windward quarter of the roof arc, 12 lb per square foot suction ; (2) central half of the roof arc, 13·52 lb per square foot suction ; (3) leeward quarter of the roof arc, 9 lb per square foot suction.

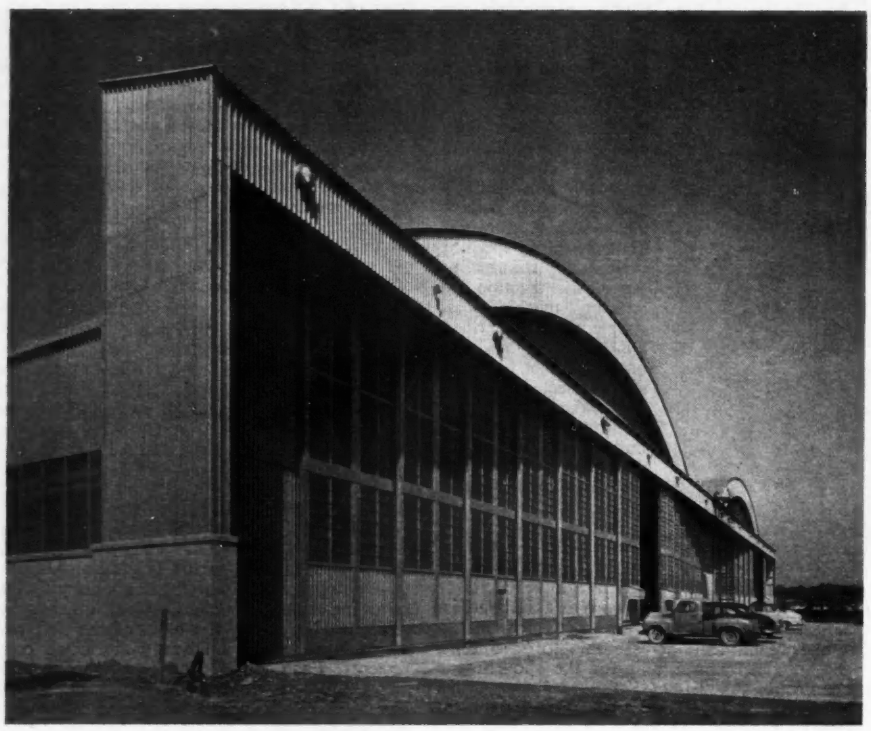
Each hangar roof is supported on six three-hinged trussed arches. The arches have a depth of 8ft at the base and at the crown hinges, and have a uniformly increasing depth toward the eaves where the section is 14ft in depth. The rise at the centre of the 278ft span is 76ft centre to centre of the hinge pins. Each arch was completely fabricated from structural angles and plates. The gusset plates for the attachment of the arch web system were shop welded to the arch chords, and all the web members were punched and transported loose for ground assembly before erection. One complete half-arch was assembled in the fabrication shop at Columbus, Ohio, to check the accuracy and fit of all members. The chords for all other arches were then jigged on the basis of the first trial assembly to ensure uniformly fabricated components. Each complete arch assembly weighed 38 tons exclusive of purlins, bracing and sheeting. In the main bracing system, every fourth purlin is a knee-braced truss, framing between arches, and extending longitudinally for the complete length of the hangar. These trusses form the main longitudinal bracing system in the planes of the arch chords. Diagonal wind bracing was placed in both the upper and lower chord systems in all bays except the central bay.

With the hangar structures resting on a new fill of inadequate bearing capacity, it was necessary to support the entire structure on piling. " Franki " concrete displacement piles, varying in length up to 45ft, support the pads under each arch bearing, under the door rail supports at the front of each hangar unit, and under the main bearing points for the wall construction. Beams placed between the main bearing point support both the exterior and interior wall construction.

The bulk of the structural steelwork was transported by rail from the fabricating shop to a siding approximately 5 miles from the erection site. At the site, the arches were assembled into approximate quarter-span sections on a large concrete apron, bolted and painted with a first



Three-hinged arch framework of hangar at Greater Pittsburgh Airport



External appearance of completed hangar

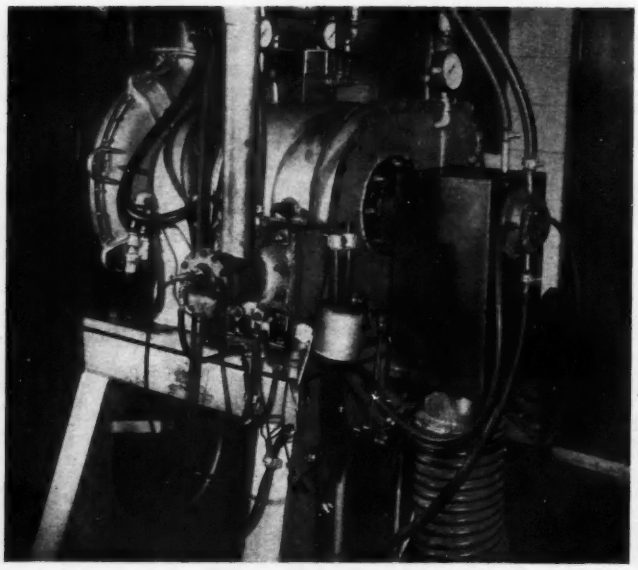
coat of aluminium paint, and stacked in a convenient manner until they were required in the erection procedure. The arch quarter sections at each side of the span were then erected with the base hinge pins driven into place. Temporary erection frames were placed under the quarter sections to hold them at the proper elevation. All purlins, struts and bracing were then bolted to the pair of quarter arch sections at each end, forming a well-braced rigid structure. Finally, two cranes with 90ft booms and 25ft jibs raised the two centre quarter sections into place, after which the chord splices were made and the crown hinge pins were driven into place. Before the arch load was released the arch ties below the floor line were pretensioned and connected to transmit the arch thrust. After complete erection of all struts, purlins and bracing in the first bay, the arches were erected, one at a time, utilising the temporary erection frames. The twelve arches, the purlins and the bracing were erected in approximately 9200 man-hours.

The roof and walls of the main hangar are covered with galvanised copper-bearing steel sheeting. The sheeting has a 2in deep square corrugation and the ribs in the sheet are spaced at a centre distance of 8in. Rigid Fibreglass insulation board is suspended beneath the roofing and is supported on formed steel retainers. The roofing and insulation were erected at the same time from the top side of the roof, thus eliminating the need for scaffolding. The sidewalls above the masonry curtains are insulated with rigid Fibreglass insulation board. Our illustration above shows the external appearance of the completed hangar.

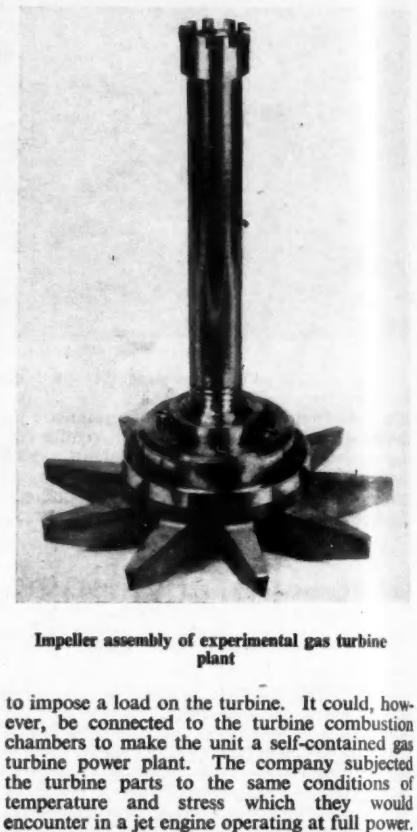
The total area of the hangar is 74,000 square feet. Office and shop space between and at the rear of the hangars provide an additional 26,000 square feet of floor area. Each hangar is equipped with a set of electrically operated bottom-rolling hangar doors which permit a clear opening 40ft high by 255ft wide. The entire superstructure of the hangar was designed, fabricated and erected for the Allegheny County Department of Aviation by the Ideco Division of the Dresser-Stacey Company, Columbus, Ohio.

Experimental Gas Turbine Test Plant

It has been announced by Kennametal, Incorporated, of Latrobe, Pennsylvania, that its experimental 125 h.p. gas turbine plant recently underwent a continuous 100-hour operation at a temperature of 1850 deg. to 1900 deg. Fah. and at a speed of 30,000 r.p.m. The tests were conducted on the specially designed experimental turbine, which is shown in the accompanying illustration. The turbine itself is situated in the central water-jacketed housing and one of the combustion chambers may be seen projecting toward the centre of the photograph. A second combustion chamber projects on the opposite side. The water-jacketed exhaust chamber and the exhaust pipe are on the right end of the assembly. On the left end of the assembly is a compressor adapted from an aircraft engine supercharger which is used merely to impose a load on the turbine. It could, however, be connected to the turbine combustion chambers to make the unit a self-contained gas turbine power plant. The company subjected the turbine parts to the same conditions of temperature and stress which they would encounter in a jet engine operating at full power. In particular, this unit has permitted the testing of new component designs required to facilitate the optimum use of the company's high-temperature sintered titanium carbide known as "Kentanium." Our second illustration shows the 7in diameter "Kentanium" turbine impeller attached to the turbine shaft.



Experimental 125 h.p. gas turbine plant



Impeller assembly of experimental gas turbine plant

Brake Material Testing Dynamometer

An inertia dynamometer which has been installed in a new laboratory of the Johns-Manville Research Centre is stated to be capable of producing 100,000ft-lb of braking torque and 51,000,000ft-lb of kinetic energy. This machine is to be used for testing brake materials for aircraft, road and rail vehicles, &c., and is claimed to be one of the largest and most versatile dynamometers yet constructed. It weighs over 200 tons and is driven by an induction motor set at a stepless range of speeds up to 1500 r.p.m. An eddy current clutch drives a flywheel consisting of sixteen removable dynamically balanced discs weighing 27 tons. Coupled to the flywheel shaft through a flexible coupling is the gear reduction unit of the machine, which is rated at 5800 h.p. at 300 r.p.m. It has two output shafts for speeds up to 300 r.p.m. and 1500 r.p.m. respectively.

A torque stand, on which the brake equipment to be tested is mounted, is capable of taking drums up to 5ft diameter. Hydraulic cylinders are used to position the brake assemblies on the stand. Hydraulic and compressed air systems are used to maintain constant input and constant torque control on the machine. Test sequences and speeds are preselected through an electronic control panel and results are recorded on four-channel oscillographs.

Industrial and Labour Notes

Production and Distribution Censuses

In May, 1953, the President of the Board of Trade appointed a committee, under the chairmanship of Sir W. Reginald Verdon Smith, to tender advice and make recommendations as to future policy concerning the taking of censuses of production and distribution. The membership of the committee included representatives of large and small businesses engaged in production and distribution, and of the trade unions and universities. In the course of its work the committee received evidence from more than 500 organisations representing industry and trade, as well as from other interested bodies.

Last week the committee's report was published by H.M. Stationery Office, and the President of the Board of Trade stated that the Government accepted in full the recommendations which the committee had made. He also expressed the hope that the report would be accepted by industry and trade generally. The committee has recommended that, for the present, full censuses of production should be taken triennially. It suggests, however, that the Board of Trade should review the position not later than 1960 to consider whether the interval between full censuses could be increased to five years. It is also recommended that the "exemption" level, below which firms are not in general required to make detailed returns, should be raised from eleven to twenty-five persons employed. This, it is stated in the report, would provide relief to 18,000 of the 60,000 establishments now required to make detailed returns in a full census of production. In the intervening years, between the full censuses of production, the committee recommends the taking of sample surveys to provide the information needed annually for the Government's estimates of national income and expenditure. Here, it is suggested that, as far as possible, firms should be given advance notice if required to make a return in the sample survey. The committee's main recommendation about censuses of distribution is that a full census should be taken once in every ten years, and that sample surveys should be made during the interval so that periodic checks on the census information will be available every third or fourth year. In a sample survey of distribution not more than 10 per cent of the smaller independent traders would be covered, and they would be chosen from representative areas of the country. There are several detailed recommendations in the report, covering such matters as the simplification of census forms, increased use of sampling techniques, longer notice to firms of census questions, and improvements in the presentation of results.

It has already been stated that a full census of production relating to 1954 is to be taken next year, and the necessary Order, prescribing the matters about which returns will be required, has now been made by the Board of Trade. The statutory form for establishments employing more than ten persons will include questions on working proprietors; number of employees; wages and salaries, and employers' contributions to superannuation and other pension funds; capital expenditure on plant, machinery, vehicles and new building work; work given out; stocks at the beginning and end of the year; transport payments; materials and fuel purchased, and output.

L.C.C. Building Contracts

Since the war the London County Council's standard form of building contract for major works has incorporated a fluctuations clause in respect of rates of wages and prices of materials. We are informed, however, that the Council has throughout accepted the principle that a reversion to fixed-price tendering is desirable as soon as circumstances permit. So far as wages are concerned, the Council considers that a point of reasonable stability has not yet been reached, but it considers that prices of building and civil engineering materials have been as stable over the last two years as they were before the war.

As a first step, therefore, towards the adoption of the principle of fixed-price tendering, the L.C.C. has decided to introduce experimentally for a limited period a simple system of alternative tendering. For all jobs using orthodox materials where the contract period does not exceed two years, contractors will be invited to tender on two bases: (*a*) as at present with the fluctuations clause applying to both wages and materials; and (*b*) with a fluctuations clause applicable to wages only.

Shift Working

Just over a year ago, the Minister of Labour, acting on the advice of his National Joint Advisory Council, wrote to a number of employers' organisations and trade unions asking them to consider whether there was scope in their industries for the introduction or extension of the double day-shift system. In order to obtain some up-to-date information on the different kinds of shift work systems in operation the Ministry made arrangements to collect statistics from certain industries and services in the United Kingdom. Its inquiry covered the manufacturing industries generally, mining and quarrying (other than coal), gas, electricity and water supply, national government service and the laundry and dry-cleaning services.

The statistics collected relate to the first pay week in May, except for Scotland, where the figures for the last pay week in April were taken. The total number of wage earners (including part-time workers) covered by the returns received was 5,557,500. The Ministry of Labour says that of the wage earners shown on these returns, 51 per cent were employed in establishments where some form of shift working was in operation, though only 12 per cent, or 663,500 people, were reported to be actually working on shift systems. Of the 663,500 people who were engaged on shift work, 46 per cent were on three-shift systems, 24 per cent were on alternating day and night shifts, 16 per cent worked double day-shifts, 4 per cent participated in evening shifts for part-time workers, and 10 per cent were on night shifts.

National Joint Advisory Council

On Wednesday of last week, a meeting of the National Joint Advisory Council was held in London under the chairmanship of the Minister of Labour, Sir Walter Monckton, Q.C. The Council is composed of representatives of the British Employers' Confederation, the Trades Union Congress, and the nationalised industries.

One matter considered by the Council was the Minister of Labour's approach—as mentioned in the preceding note—to selected industries inviting them to examine the advantages of double day-shift working. It was stated that about forty organisations had put forward their views, nearly half of them stating that some form of shift working was already operating in their industry. Only three organisations reported an extension of double day-shift working since the approach made by the Minister a year ago. The remaining organisations said either that double day-shift working was not suitable for their industries or that it was unnecessary in present circumstances for such reasons as shortage of materials, labour or orders.

The Council had before it an up-to-date appreciation of the economic situation. It was decided, however, to defer detailed discussion of it until the next meeting, which is to be held towards the end of January.

Changes in Wage Rates

The Ministry of Labour has stated that, during September, changes in wage rates resulted in an aggregate increase of about £41,000 in the weekly full-time wages of 309,000 workpeople and in a decrease of about £300 for 13,000 workpeople. Those receiving increases included workers in the iron and steel industry in some districts, where such increases were payable under sliding scale arrangements based on the index of retail prices. On the other hand, the sliding scale arrangement resulted in small decreases for iron and steel workers in a few districts and for iron ore miners and limestone quarrymen in Cumberland. In the first nine completed months of this year, changes in wage rates resulted in an aggregate increase, estimated at £2,636,300, in the weekly full-time wages of 8,378,000 workpeople. In the comparable period of last year, there was an increase of £1,879,000 in the weekly full-time wages of 6,398,000 workpeople. At the end of September this year, the index of rates of wages (June, 1947=100) stood at 143 for all workers, compared with 137 a year earlier.

Trade Disputes

According to information published in the *Ministry of Labour Gazette*, there were 225 stoppages of work in progress at some time in September as a result of industrial disputes. The number of workers involved in them, directly and indirectly, was 40,400 and the aggregate number of working days lost was 124,000. In the preceding month 82,000 working days were lost on account of 146 disputes in which 24,700 workers were involved.

There were 165 stoppages of work through disputes in the coal mining industry in September, resulting in a loss of 47,000 working days. The strike of ship repair workers in various districts in London began during September, and according to the Ministry's statistics more than 8000 workers were involved in it during the month. That stoppage, which is still in progress as we go to press, is said to be a protest against the discharge of certain redundant electrical workers who are members of the Electrical Trades Union. Other unions in the ship-repairing industry joined the strike in support.

In the nine months up to the end of September last, there were 1469 stoppages of work through disputes reported to the Ministry of Labour. The number of workers involved in them has been estimated at 275,700, and the time lost 973,000 working days. In the corresponding period of 1953, there were 1220 stoppages reported, involving 197,900 workers, and causing a loss of 840,000 working days.

End of the Dock Strike

Last Saturday, dock workers in London and in various other ports in the country decided to resume work after a strike which had lasted nearly a month. The principal point on which the dispute started originally was the matter of overtime working, it being held by the men that overtime should be voluntary and not compulsory. Another issue was a dispute over the sorting of meat cargoes. The workers who determined upon strike action are members of the National Amalgamated Stevedores and Dockers, which union supported the strike. They were subsequently joined by members of the Transport and General Workers Union, which did not approve the action taken.

The Minister of Labour appointed a court of inquiry on October 18th, under the chairmanship of Sir Raymond Evershed, to examine the causes of the dispute. The court submitted an interim report last week in which it declared that the overtime issue was one which should be capable of solution without difficulty by the established industrial machinery. The Trades Union Congress has described the strike as "irresponsible and unnecessary," and it has been stated that imports and exports to the value of £200,000,000 have been held up on account of it. It has also been estimated that normal working in the affected ports is unlikely to be restored for a month.

Notes and Memoranda

Air and Water

NAVAL ARCHITECTS' SPRING MEETING.—It is announced that the spring meeting of the Institution of Naval Architects for 1955 will open on Wednesday, March 30th.

SMALL BOAT BUILDING.—We have received a copy of Bulletin No. 141 of Aero Research Technical Notes, which deals with " Aerolite 300 " for boat building, and describes the development of the cold-moulded hull and glued clinker-built hull.

SILENCING PENS FOR JET AIRCRAFT.—In THE ENGINEER, October 8th, page 489, we described the primary Cullum silencing jet mufflers and the acoustically lined pens around them, which have been installed at an aircraft manufacturers' airfield for silencing the " running up " of turbo-jet engines. We now learn that this scheme was under the direction of Mr. H. Q. A. Reeves, a consulting engineer who also designed the pens.

Miscellanea

INTERNATIONAL MOTOR SHOW.—On page 587 of last week's issue in a reference in our article on the International Motor Show to the new Wolseley " Six-Ninety," we accidentally implied that " Six-Eighty " is no longer being made or offered for sale. That is untrue. Both models are obtainable.

SOUND ABSORBENT TREATMENTS.—The latest in the Building Research Station's series of digests—No. 36—is concerned with sound absorbent treatments, and outlines the use and properties of a number of building materials as sound absorbent linings in rooms and auditoria. The digest is published by H.M. Stationery Office.

I.MECH.E. SUMMER MEETING.—The council of the Institution of Mechanical Engineers has accepted an invitation from the chairman and committee of the Southern Branch to hold next year's summer meeting in Southampton and district. It is proposed that the meeting should take place during the week beginning Monday, July 4th.

HIGH-BAY LIGHTING UNIT.—A high-bay industrial lighting unit has been developed by Holophane, Ltd., Elverton Street, London, S.W.1. It consists of a cast aluminium canopy fitted with a heat-resisting glass reflector, and is designed for use with the 1000W " MB/V " mercury discharge lamp. Four metal straps forming part of the assembly allow for supplementary strap suspension or for stirrup mounting.

FLAMEPROOF LIGHTING FITTING AND JUNCTION BOX.—An aluminium alloy flameproof junction box and lighting fitting have been developed by E. N. Mackley and Co., of Hawks Road, Gateshead. The junction box has four-way socket connections, which can be sealed off when not required. The lighting fitting has a dome of armour plate glass and an aluminium reflector treated to improve its resistance to atmospheric corrosion.

LECTURES IN CONCRETE TECHNOLOGY.—We have received from the Cement and Concrete Association, 52, Grosvenor Gardens, London, S.W.1, a list of lectures, covering all the various branches of concrete technology, which are to be given throughout the country during the coming winter. The lecture courses listed are not necessarily organised by the Association, but the details given in the list includes, in each case, mention of the organising body.

NATURAL GAS.—On Monday last the Minister of Fuel and Power was questioned in the House of Commons as to the progress being made in Great Britain in the search for natural gas. In a written reply the Minister says that the results of deep drilling in Scotland and in Sussex, and of extensive geophysical surveys in Yorkshire and Lincolnshire are now being examined. Further drilling is being considered in the light of information thus obtained.

GAS USE IN INDUSTRY.—Last week the Gas Council, in association with the South Eastern Gas Board, arranged a press visit to the works of Lines Bros., Ltd., at Merton, London, S.W.19, which is claimed to be the largest toy factory in the world. The purpose of the visit was to show the extensive use of gas in the processes and equipment involved in toy and baby carriage manufacture. This factory is at present using 50,000,000 cubic feet of gas a year, and this consumption will increase by a further 10,000,000 cubic feet next year.

MR. W. R. BELDAM.—We regret to announce the death of Mr. W. R. Beldam, a director of Beldam Asbestos Company, Ltd., and other companies, which occurred on October 30th. After serving his time with W. H. Allen, Sons and Co., Ltd., of Bedford, Mr. Beldam joined his brother, Ernest, in the family business on his father's death in 1903. His special interest was in technical and production problems and in 1923 he became founder director of Auto-Klean Strainers, Ltd. In later years Mr. Beldam was also chairman of the Submerged Log Company, Ltd.

ROYAL SOCIETY OF ARTS.—The Royal Society of Arts has now announced the result of its bicentenary competition for forecasts of practical aspects of life on this earth in the year A.D. 2000 The judges appointed by the council of the Society were unable to make any recommendation for the first prize of £250 or the second prize of £100, but the council has made the following awards : a prize of £50 to Wing Commander T. R. Cave-Browne-Cave, M.I.Mech.E., F.R.Ae.S., of Southampton, for a scheme for rooftop roadways ; a prize of £20 to Mr. C. E. H. Watson, M.I.C.E., of Walton-on-Thames, for a system of underground roadways for London ; a prize of £10 to Mr. F. R. East, of Horbury, near Wakefield, for a paper on synthetic food ; a prize of £10 to Rev. C. W. Gibbons, of Cambridge, for a paper on education, and a prize of £10 to Dr. M. B. McEvedy, of Manchester, for a paper on microbiological products. The entries submitted numbered 184 and for the purpose of judging were classified into eight groups, for each of which a panel of experts was appointed. The entries were allocated among these groups as follows : agriculture, 11 ; building and planning, 19 ; domestic, 18 ; education, 26 ; industry, 25 ; medical, 12 ; recreation and other cultural and social matters, 21, and transport and communications, 52. The Council has decided to invite the first two prizewinners to read their essays as papers at one of the Society's meetings, on Wednesday, November 24th, at 2.30 p.m.

GLASCARNOCH TUNNEL.—The driving of the 5 miles long Glascarnoch tunnel, part of the North of Scotland Hydro-Electric Board's Conon Valley scheme, was completed on Saturday, October 30th, when Sir Hugh Mackenzie, deputy chairman of the Board, fired the final blasting charge. The Glascarnoch tunnel, which is 10ft in diameter, will carry water from a new loch formed in the valley of the River Glascarnoch by a dam near Aultguish, Ross-shire, to a 24MW generating station on the shores of Loch Luichart, 530ft below. The contractor is A. M. Carmichael, Ltd., and the civil engineering consultants are Sir Alexander Gibb and Partners.

HYDRO-ELECTRIC POWER STATION AT NIAGARA FALLS.—In our issue of October 1st, a brief description was given of the Sir Adam Beck-Niagara No. 2 generating station, which was recently opened at Niagara Falls. Mention was made of the pumped storage scheme associated with this power station, which is at present under construction. We now learn that the proposed output of the pumped storage scheme has been altered and six reversible pump turbines, each of 52,500 h.p. are to be installed to give a total capacity of 235MW for this section of the scheme. The Hydro-Electric Power Commission of Ontario has placed an order for the pump turbines with the English Electric Company, Ltd.; this firm is to design the machines at Rugby, for manufacture at its Toronto works.

OPENCAST COAL CONTRACT,—What is stated to be the largest single contract for working opencast coal ever to be placed in this country has been awarded by the opencast executive of the National Coal Board to Wilson Lovatt and Sons, Ltd., of Wolverhampton. The contract is for producing about 4,000,000 tons of coal over the next ten years from a hillside site at Tirpentwys, near Pontypool, Monmouthshire. The seam of coal to be recovered consists of two leaves of 48in and 30in thickness and the " cut " will go down to 150ft at the deepest points. The overburden will be removed by two walking drag-line excavators and two rock-shovel excavators, all electrically operated. The coal will be brought to the surface in motor dump-trucks and passed by belt conveyors through crushers and screens to the railway wagons. A laboratory for the regular testing of the outgoing wagon loads has been constructed at the sidings.

APPRENTICE TRAINING SCHEME.—We have received details of the apprenticeship scheme offered by the Dowty Equipment, Ltd., Cheltenham. The scheme provides for the training of three grades of apprenticeship according to the educational or academic qualifications of the apprentice. The craft apprenticeship scheme provides nine to twelve months' basic training in a special fitting and machinery shop, two years' general experience in which the apprentice specialises in two or more metal working processes and another two years in the final department, such as machining, fitting, tool making, &c. A technical apprenticeship requires an education to general certificate level. After the same basic training the apprentice can choose from a wider range of departments which include the drawing office, jig and tool design, testing and heat treating. His final training is in either the drawing office, stress office, research or production departments. Student apprentices starting at eighteen years of age require advanced or national diploma. They receive the same basic training and general experience as the technical apprentices.

Personal and Business

GENERAL SIR G. IVOR THOMAS, G.C.B., has joined the board of Rubber Improvement, Ltd.

MR. MAURICE WARDLE has been appointed a trainee director of Qualcast, Ltd., Victory Road, Derby.

MR. A. W. EVANS has been appointed general sales manager of Air Control Installations, Ltd., Ruislip, Middlesex.

MR. J. R. QUERTIER, A.C.G.I., has joined the staff of Consolidated Pneumatic Tool Company, Ltd., 232, Dawes Road, London, S.W.6.

MONSANTO CHEMICALS, Ltd., 8, Waterloo Place, London, announces that Mr. J. W. Urban has been appointed a director of the company.

LIEUT.-COLONEL D. W. R. WALKER has been appointed joint managing director of Flexible Drives (Gilmans), Ltd., 195, High Street, Smethwick, 41.

THE BRITISH ELECTRICITY AUTHORITY announces the appointment of Mr. S. A. Clarke, M.I.E.E., as electrical engineer (construction) to the London division.

B.S.A. TOOLS, Ltd., states that it has been appointed sole representative in Canada for the Abrasives Division of the Elgin National Watch Company, Elgin, Illinois, U.S.A.

INTERNATIONAL HARVESTER COMPANY OF GREAT BRITAIN, Ltd., 259, City Road, London, E.C.1, states that its telephone number has been changed to Clerkenwell 8422.

MR. W. LAWSON HURDMAN, M.I.Mech.E., has been appointed general production manager of the Owen Organisation at the head office at Darlaston, South Staffordshire.

SIR LEONARD LORD, chairman and managing director of the British Motor Corporation, Ltd., has been elected a vice-president and president-elect of the Institution of Production Engineers.

MR. WALTER BRYANT has been appointed borough engineer and surveyor of Tottenham in succession to the late Mr. R. J. Williams. Mr. Bryant has been deputy borough engineer since 1940.

THE OAKLAND METAL COMPANY, Ltd., 142, New Bond Street, London, W.1, has been appointed distributor in this country of " Diamol " lubricant and cleaning oil for diamond wheels, dies and tools.

SHAW PROCESSES, Ltd., 25, Clyde Vale, Forest Hill, S.E.23, has formed a subsidiary company, entitled Shaw Processes (Australia) Pty., Ltd., in association with Vericast, Ltd., Victoria, Australia.

THE BRITISH ALUMINIUM COMPANY, Ltd., states that Mr. P. Ralph has been appointed manager of the Scottish branch sales office in succession to Mr. M. J. J. Richards, who has become assistant manager of the London branch sales office.

MR. V. HARBORD and MR. T. G. HOWARD state that Mr. W. A. C. Newman is joining them as a consultant in the firm of Riley, Harbord and Law, Parliament Mansions, Abbey Orchard Street, London, S.W.1. Mr. Newman is shortly retiring from the position of chemist and assayer of the Royal Mint.

GRESHAM AND CRAVEN, Ltd., announces the appointment of Lieut.-Colonel Harry Gresham as a director and London manager. A London office is shortly to be opened at 15, Whitehall, S.W.1, pending which communications should be sent either to Ordsall Lane, Salford, 5, Manchester, or to 14, Great Peter Street, London, S.W.1 (telephone, Abbey 5964).

ALFRED HERBERT, Ltd., Coventry, announces an arrangement whereby it is now co-operating with Coventry Gauge and Tool Company, Ltd., and Taylor, Taylor and Hobson, Ltd., in the sale of their engineers' measuring instruments in the United Kingdom. Alfred Herbert, Ltd., already handles the sales in the United Kingdom of Hilger and Watts, Ltd., and Sigma Instrument Company, Ltd., so that the five companies are now co-operating in the supply of measuring instruments.

FORD MOTOR COMPANY, Ltd., and Ransomes Sims and Jefferies, Ltd., state that, from January 1st next, the manufacture of all the farm machinery which they have developed jointly for use with the " Fordson Major " tractor will be undertaken by Ransomes Sims and Jefferies, Ltd., together with the manufacture of all spare parts. Distribution to the home market will be carried out by Ransomes Sims and Jefferies, Ltd., and Ford Motor Company, Ltd., will continue to control the overseas distribution.

Launches and Trial Trips

ROLLO, cargo ship ; built by Henry Robb, Ltd., for Ellerman's Wilson Line, Ltd.; length between perpendiculars 290ft, breadth moulded 48ft 6in, depth moulded to upper deck 27ft, deadweight 2400 tons on 17ft 9in mean draught, service speed 13 knots ; twelve passengers ; four holds, derrick complement includes 5-ton derricks and two 10-ton derricks, steam deck machinery, two 60kW and one 30kW steam-driven generating sets ; triple-expansion, direct-acting, surface condensing, reciprocating engine, cylinder diameters 20in, 34in and 54in by 39in stroke, Bauer-Wach exhaust steam turbine, steam supplied at 225 lb per square inch by two cylindrical multitubular boilers. Trial, October 12th.

FOUNTAINS ABBEY, cargo ship ; built by Hall Russell and Co., Ltd., for Associated Humber Lines ; length overall 256ft, length between perpendiculars 240ft, breadth moulded 38ft 6in, depth moulded to shelter deck 21ft 6in, deadweight 1240 tons on 13ft 5in draught ; twelve passengers ; three holds, six 7-ton and one 15-ton derricks, electrical deck machinery ; Kincaid-Polar diesel engine 2100 b.h.p. at 220 r.p.m. Trial, October 12th.

ST. ROGNALD, coaster ; built by Alexander Hall and Co., Ltd., for the North of Scotland, Orkney and Shetland Shipping Company, Ltd.; length overall 244ft, breadth moulded 39ft, depth moulded to shelter deck 21ft 6in ; twelve passengers ; deadweight 900 tons ; two holds, one 3-ton, four 5-ton and one 15-ton derricks ; electric deck machinery, two 100kW and one 35kW diesel-driven generators ; Denny-Sulzer two-stroke, trunk piston diesel engine, 2100 b.h.p., service speed 13 knots. Launch, October 14th.

MELIKA, oil tanker ; built by the Furness Shipbuilding Company, Ltd., for Afran Transport Company, of Liberia ; length overall 661ft 7in, length between perpendiculars 630ft, breadth moulded 87ft, depth moulded 45ft 6in., deadweight 32,020 tons on 34ft 2in summer draught ; thirty cargo oil tanks, one main cargo oil pump room, four 4500 gallons per minute centrifugal turbine-driven cargo oil pumps, four 150 tons per hour stripping pumps, steam deck machinery ; two 500kW turbine-driven alternators, one 100kW diesel-driven alternator ; one set double reduction geared turbines by Richardsons, Westgarth (Hartlepool), Ltd., normal power 12,500 s.h.p. at 105 r.p.m. of propeller, maximum power 13,750 s.h.p. at 108 r.p.m., steam supplied at 600 lb per square inch and 850 deg. Fah. by two Foster Wheeler " D " type boilers. Trial, October 14th.

British Patent Specifications

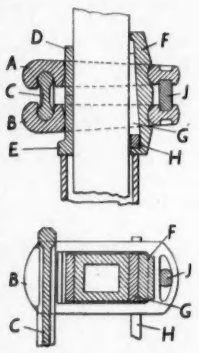
When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification.

Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 2s. 8d. each.

MINING ENGINEERING

716,058. March 7, 1952.—CLAMPING LOCK FOR PIT PROPS, Gutehoffnungshutte Oberhausen Aktiengesellschaft, (22a) Oberhausen (Rhineland), Germany.

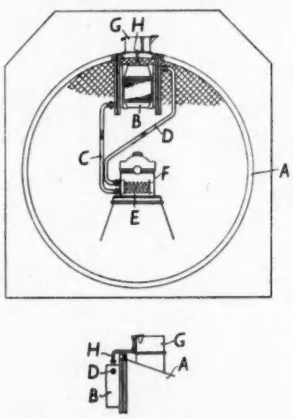
The lock consists of two annular or loop members *A* and *B* applied to the prop in such a way as to be capable of pivoting on it, the members being driven apart by means of a tightening wedge *C*. On the side of the lock on which the tightening wedge is accommodated a pressure plate *D* having a foot or lug *E* is provided as an intermediate layer between the lock band and the upper prop part. On the side of the lock remote from the tightening wedge an intermediate plate *F* is supported against the lower prop part and held at such a distance from the upper part that a self-sliding compensating wedge *G* can be inserted between the plate *F* and the upper prop part. This compensating wedge *G* is arrested by means of a self-locking transverse wedge *H*. The rear side of the intermediate plate *F* may be so shaped that the annular members *A* and *B* are supported, as shown in the drawing, the annular members accommodating between them on this side a resilient body *J* which, when the lock is released, holds the rings *A* and *B* in their initial position.—*September* 29, 1954.



No. 716,058

716,027. February 12, 1951.—COOLING ARRANGEMENTS FOR THE BEARINGS OF BLOWERS FOR UNDERGROUND OPERATION, Koninklijke Machinefabriek Gebr. Stork and Co., N.V., No. 1, Industriestraat, Hengelo (O), The Netherlands.

As shown in the drawing, the intake *A* of the blower supports a reservoir *B*, which serves as a heat exchanger and which by means of a supply conduit *C* and a return conduit *D* is connected to an oil cooler *E* in the bearing casing *F*. Above the heat exchanger a supply tank *G* is supported on the intake *A* of the blower and connected to the heat exchanger *B* by means of a pipe *H*. Circulation of the coolant liquid is obtained by thermo-syphonic action, whereby a relatively small quantity of liquid is automatically circulated and takes up heat in the oil cooler *E* of the bearing and transmits the heat in the heat exchanger to the air flowing in contact with the heat exchanger. The heat exchanger is preferably arranged at the intake where the air is cooler than at the discharge side of the blower.—*September* 29, 1954.

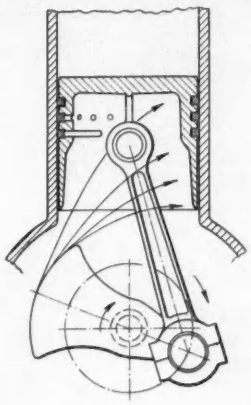


No. 716,027

INTERNAL COMBUSTION ENGINES

716,070. May 22, 1952.—CYLINDER LUBRICATION, Daimler-Benz Aktiengesellschaft, Stuttgart-Untertürkheim, Germany.

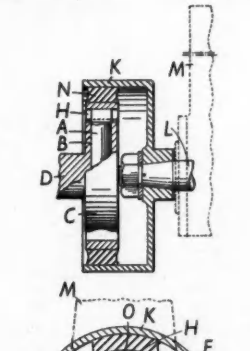
The invention relates to especially short-stroke engines. Referring to the drawing, as the crankshaft turns the oil is thrown by the balancing weight to the side of the piston as indicated by the arrows. To prevent the oil from flowing out on this side of the piston and passing into the combustion space, the side is made without the usual return openings. On the opposite side, openings or slots are provided for the oil flowing back from the cylinder wall to the interior of the piston. This opposite side is the one which is heavily loaded when the piston is under combustion pressure during a working stroke and such loading is effective for forcing the oil through the apertures. The oil wiping rings or their annular grooves are so constructed that the oil can flow without appreciable resistance from the non-loaded side to the loaded side of the piston.—*September* 29, 1954.



No. 716,070

716,510. December 7, 1951.—A FUEL INJECTION PUMP DRIVE TO PREVENT POSITIVE REVERSE ROTATION OF THE ENGINE, Arthur Freeman Sanders, M.I.M.E., Redinnick House, Penzance, Cornwall.

The invention relates to a means for driving a fuel injection pump of a compression ignition vehicle engine which prevents the engine from being rotated in reverse by preventing fuel reaching the engine.



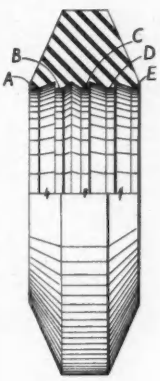
No. 716,510

Referring to the drawing, a pawl *A* is mounted in a bore *B* formed in a flange element *C* integral with a drive shaft *D* driven by the engine. The pawl is prevented from rotation in the bore by a grub screw *E*, the head of which is contained in a groove. The pawl is biased by a spring so that its nose contacts an abutment *H* formed on a spiral cam track *J*, carried by a cup-shaped element *K* mounted on the driven shaft *L* of a fuel injection pump *M*. The cam track is resiliently mounted within the element *K* by means of rubber blocks *N* so as to reduce the noise of operation of the device. With the engine running in its normal and proper direction the drive shaft *D* is rotated in a clockwise direction, as shown in the lower view. Centrifugal force, assisted by the spring maintains the pawl projecting from the bore with its nose contacting the abutment *H*, whereby the fuel injection pump is driven in its normal direction for supplying fuel. In the event of the direction of engine rotation becoming reversed, the direction of rotation of the drive shaft *D* will also be reversed and will cause the pawl *A* to rotate in an anti-clockwise direction as shown in the lower view, and to break contact with the abutment *H* so that no drive will be transmitted to the shaft *M* of the fuel injection pump and the element *K* will remain stationary with the pawl riding on the cam track. As the pitch of the cam track increases, the pawl will be forced back into the bore *B* against the action of the spring, but on the pawl reaching the edge of the abutment the spring will force the pawl out until it again rides on the initial portion of the cam track. The nose of the pawl enters a small recess *O* in the cam track as will clearly be seen in the drawing, in order to prevent the pawl from breaking contact with the abutment when subjected to backlash of the engine cams.—*October* 6, 1954.

BEARINGS AND SUPPORTS

716,032. July 20, 1951.—PISTON-ROD PACKING RINGS, Armstrong's Patents Company, Ltd., Eastgate, Beverley, Yorkshire; and Frederick Arthur Clarke, 11, Lawns Court, The Avenue, Wembley Park, Middlesex.

The object of the invention is to provide a packing ring for the piston-rod of a telescopic hydraulic shock absorber. In the drawing is shown a packing ring of resilient material, such as synthetic oil-resisting rubber, grooved on its operative face to present five spaced annular lips *A*, *B*, *C*, *D* and *E*. The lips *A* and *B* have a face at one side radial to the axis of the ring, and a face at the other side inclined to the ring axis. The lips *C*, *D*, *E* have faces corresponding to those of *A* and *B* but facing the other way. All the lips have an intermediate face parallel to the axis of the ring. The lips *A* and *B* are shaped to exclude passage of dirt and other foreign matter and the lips *C*, *D*, *E* are shaped to exclude passage of fluid. In another preferred form of construction (not shown) the packing ring is grooved to present one dirt excluding lip, and two lips to prevent the flow of fluid.—*September* 29, 1954.

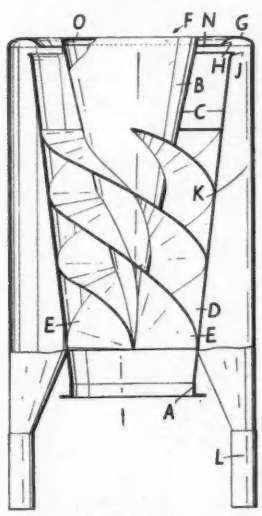


No. 716,032

SIEVES AND SEPARATORS

716,383. October 16, 1951.—CENTRIFUGAL GRIT ARRESTERS, Wm. Cory and Son, Ltd., Cory Buildings, Fenchurch Street, London, E.C.3. (*Inventor: John Norman Williams.*)

The invention relates particularly to devices for separating grit from flue gases exhausted from furnaces. The drawing shows a grit arrester for use in separating grit in boiler flues, in the form of a cowl secured to the top of the chimney or flue. The lower end *A* of the cowl is adapted to be secured to the chimney top and is shaped internally similar to the chimney flue. The cowl interior is tapered and a conical deflector *B* is arranged in the tapered duct apex downwards. The duct interior and the



No. 716,383

outside of the cone are formed with straight or smoothed curved surfaces *C* to prevent any sudden change of direction of the gas flow ; these surfaces are so shaped and dimensioned that the cross sectional area of the annular gas passage *D* thus formed is constant right through the cowl so that there is no substantial change in the velocity of the flow of the gases. The lower end *A* of the cowl below the conical portions is cylindrical. One or more helical vanes *E* are arranged in the passage so that as the gases flow through the cowl it causes them to whirl and the grit particles are thrown outwards. At the upper end *F* of the cowl a ring *G* is arranged round and above the outer periphery of the annular duct *D*, the ring having an inner lip *H* over-lapping the outer periphery *J* of the annular duct ; the grit on reaching the top of the duct is flung out by centrifugal force beneath the ring *G* while the gases continue to flow up into the atmosphere. Below the ring and round the cowl an outer chamber *K* is provided into which the separated grit is deposited. One or more pipes *L* lead down from this chamber to discharge the grit. The height of the ring *G* relative to the lip *J* may be adjustable by any suitable means which may be operated from the base of the chimney or from any other suitable easily accessible point, so that the separation of the grits may be controlled. The upper end of the cone may be curved off as at *J* round its periphery and the inner lip *N* of the annular ring *G* may be curved up to facilitate the flow of the gases. The cone preferably has a closed top *O* which may be shaped to assist in the maintenance of substantially constant velocity of gas flow. The pitch of the helix or helices *E* may be varied, but preferably each helix makes substantially one complete revolution in its length.—*October* 6, 1954.

Catalogues

CLAYTON CRANE AND HOIST COMPANY, Ltd., Irwell Chambers, Union Street, Liverpool, 2.—Publication No. 4888, "The Clayton Hoist and its Place in Industry."

ENGLISH ELECTRIC COMPANY, Ltd., Traction Department, Bradford.—Publication TD/102A, illustrating and describing diesel-electric shunting locomotives.

BOUND BROOK BEARINGS, Ltd., Trent Valley Trading Estate, Trent Valley Road, Lichfield, Staffs.—Descriptive brochure entitled "Bound Brook Bronze Filters."

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

BELFAST ASSOCIATION OF ENGINEERS

Wed., Nov. 17*th.*—College of Technology, Belfast, "Instruments and Automatic Control in the Boiler House," S. R. Halsey and J. H. Whitaker, 7.30 p.m.

BRITISH INSTITUTION OF RADIO ENGINEERS

Wed., Nov. 10*th.*—N.E. SECTION : Neville Hall, Westgate Road, Newcastle upon Tyne, "Stereophonic Sound," R. A. Bull, 6 p.m.

Thurs., Nov. 11*th.*—SCOTTISH SECTION : Department of Natural Philosophy, The University, Edinburgh, "Nuclear Fission and Nuclear Fusion," N. Feather, 7 p.m.

Wed., Nov. 17*th.*—S. WALES SECTION : College of Technology, Cathays Park, Cardiff, "The Techniques of Power Measurements from D.C. to 5 Mc/s," G. F. Lawrence, 6.30 p.m.

CHEMICAL SOCIETY

Thurs., Nov. 18*th.*—Chemistry Lecture Theatre, Imperial College of Science and Technology, South Kensington, London, S.W.7, "Molecular Rearrangements," M. J. S. Dewar, 7.30 p.m.

DIESEL ENGINE USERS ASSOCIATION

Thurs., Nov. 18*th.*—Caxton Hall, Westminster, London, S.W.1, "Notes on the Performance of Some Two-Stroke Oil Engines," S. J. Davies and M. A. Plint, 2.30 p.m.

HULL CHEMICAL AND ENGINEERING SOCIETY

Tues., Nov. 23*rd.*—Church Institute, Hull, "Synthetic Rubbers," F. A. Jones, 7.30 p.m.

ILLUMINATING ENGINEERING SOCIETY

Tues., Nov. 9*th.*—Lighting Service Bureau, 2, Savoy Hill, London, W.C.2, "Shop Lighting," R. L. C. Tate, 6 p.m.

Wed., Nov. 10*th.*—SWANSEA GROUP : S. Wales Electricity Board's Demonstration Theatre, The Kingsway, Swansea, "The Electric Lighting in a Nylon Yarn Factory," B. C. Robinson, 6.30 p.m.

Thurs., Nov. 11*th.*—MANCHESTER CENTRE : N.W. Electricity Board, Town Hall, Manchester, "Street Lighting Costs," T. L. Robinson, 6 p.m.

Tues., Nov. 16*th.*—GLOUCESTER AND CHELTENHAM CENTRE : General Electric Co., Ltd., 2, St. Aldate Street, Gloucester, "Lighting for Enjoyment," T. O. Freeth, 6.30 p.m.——LIVERPOOL CENTRE : Liverpool Engineering Society, 9, The Temple, 24, Dale Street, Liverpool, "Lighting for Production," J. W. Howell, 6.30 p.m.

INCORPORATED PLANT ENGINEERS

Mon., Nov. 8*th.*—DUNDEE BRANCH : Mathers Hotel, Dundee, "Refrigeration Problems," G. S. R. Shaw, 7.30 p.m.

Tues., Nov. 9*th.*—MANCHESTER BRANCH : Engineers' Club, Albert Square, Manchester, "Engineering Economics," T. S. Welch, 7.15 p.m.

Wed., Nov. 10*th.*—E. MIDLANDS BRANCH : Adult Education Centre, Shakespeare Street, Nottingham, "A New Development in Laundry Washing Machines," B. A. Clark, 7 p.m.

Thurs., Nov. 11*th.*—N.E. BRANCH : Roadway House, Oxford Street, Newcastle upon Tyne, "Industrial Lubrication," N. Errington, 7 p.m.

Tues., Nov. 16*th.*—S. WALES BRANCH : S. Wales Institute of Engineers, Park Place, Cardiff, "Instrumentation and Thermostatic Controls," 7.15 p.m.

INSTITUTE OF BRITISH FOUNDRYMEN

Tues., Nov. 9*th.*—SLOUGH SECTION : Lecture Theatre, High-Duty Alloys, Ltd., Slough, Bucks, "Propeller Manufacture," J. M. Langham, 7.30 p.m.

INSTITUTE OF FUEL

To-day, Nov. 5*th.*—S. WALES SECTION : Y.M.C.A., Kingsway, Swansea, "Back-Pressure Regeneration," C. Ungoed, 6 p.m.

Mon., Nov. 8*th.*—N.E. SECTION : Chemistry Lecture Theatre, King's College, Newcastle upon Tyne, "Smoke Abatement," A. C. Monkhouse, 6.30 p.m.

Wed., Nov. 10*th.*—N.W. SECTION : Engineers' Club, Albert Square, Manchester, "Gas Turbines," F. Hickson, 6 p.m.

Thurs., Nov. 11*th.*—E. MIDLAND SECTION : Gas Showrooms, Nottingham, "Grit and Dust Collection from Industrial Furnaces," J. O'Breen, 6.15 p.m.

INSTITUTE OF METALS

Mon., Nov. 8*th.*—SCOTTISH LOCAL SECTION : Institution of Engineers and Shipbuilders in Scotland, 39, Elmbank Crescent, Glasgow, C.2, "Some Metallurgical Problems in Welding Non-Ferrous Metals," P. T. Houldcroft, 6.30 p.m.

Tues., Nov. 9*th.*—S. WALES LOCAL SECTION : Metallurgy Department, University College, Singleton Park, Swansea, "Some Aspects of Creep," J. D. Dennison, 6.45 p.m.

INSTITUTE OF PETROLEUM

Wed., Nov. 10*th.*—26, Portland Place, London, W.1, "The Chromatographic Analysis of Hydrocarbon Mixtures," B. W. Bradford, D. Harvey and D. E. Chalkley, 5.30 p.m.

INSTITUTE OF ROAD TRANSPORT ENGINEERS

Mon., Nov. 8*th.*—N.W. CENTRE : Engineers' Club, Albert Square, Manchester, "M.O.T. Regulations," H. Withington, 7.30 p.m.

Tues., Nov. 9*th.*—MIDLANDS CENTRE : Crown Inn, Broad Street, Birmingham, "Hydraulic Servo Systems for Heavy Commercial Vehicles," J. S. Arton, 7.30 p.m.

Wed., Nov. 10*th.*—E. MIDLANDS CENTRE : Mechanics Institute, Nottingham, "Some Trends in Vehicles C.I. and Petrol Engine Lubrication," F. Lawrence, 7.30 p.m.——WESTERN CENTRE : Grand Hotel, Bristol, "Vehicle Maintenance from the Aspect of Safety," A. H. Dack and J. H. Vincent, 7.30 p.m.

Thurs., Nov. 11*th.*—S. WALES GROUP : S. Wales Institute of Engineers, Park Place, Cardiff, "Road Transport Law," J. Rutter, 7 p.m.

INSTITUTE OF WELDING

Tues., Nov. 9*th.*—LIVERPOOL AND DISTRICT BRANCH : Liverpool College of Technology, Byron Street, Liverpool, "Make Do and Mend Repairs," G. G. Musted, 7.15 p.m.

INSTITUTION OF BRITISH AGRICULTURAL ENGINEERS

Tues., Nov. 9*th.*—INFORMAL MEETING : Institution of Electrical Engineers, Savoy Place, London, W.C.2, "Safety Precautions for Farm Machinery Operatives," 2.15 p.m.

INSTITUTION OF CHEMICAL ENGINEERS

Wed., Nov. 10*th.*—S. WALES GRADUATES' AND STUDENTS' SECTION : University College of S. Wales and Monmouthshire, Cathays Park, Cardiff, "Plant Management," R. A. Gregory, 7 p.m.

Thurs., Nov. 11*th.*—HINCHLEY MEMORIAL LECTURE : Geological Society, Burlington House, London, W.1, "Reflections on the Management of Heat," Professor Sir A. G. Egerton, 5.30 p.m.

Fri., Nov. 12*th.*—LONDON GRADUATES' AND STUDENTS' SECTION : Caxton Hall, Westminster, London, S.W.1, "Feed Back in Chemical Engineering Processes," F. F. Ross, 6.30 p.m.

INSTITUTION OF CIVIL ENGINEERS

Mon., Nov. 8*th.*—LEEDS BRANCH : General Lecture Theatre, Leeds, "Owen Falls, Uganda, Hydro-Electric Development," Sir Charles Westlake, T. A. L. Paton and R. W. Mountain, 7 p.m.

Tues., Nov. 9*th.*—AIRPORT MEETING : Great George Street, Westminster, London, S.W.1, "Some Considerations of Airfield Pavement Design," J. A. Skinner and F. R. Martin, 5.30 p.m.

Wed., Nov. 10*th.*—HULL BRANCH : Electricity Showrooms, Lecture Theatre, Ferensway, Hull, "Construction of Queen Elizabeth II Dock," D. C. Milne, 6.15 p.m.

Thurs., Nov. 11*th.*—MIDLANDS ASSOCIATION : James Watt Memorial Institute, Great Charles Street, Birmingham, "Pre-Stressed Concrete in Practice," J. Singleton Green, 6 p.m.

Tues., Nov. 16*th.*—ORDINARY MEETING : Great George Street, Westminster, London, S.W.1, "Present Trends in the Design of Pressure Tunnels and Shafts for Underground Hydro-Electric Power Stations," Charles Jaeger, 5.30 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS

Mon., Nov. 8*th.*—EDUCATION DISCUSSION CIRCLE : Savoy Place, London, W.C.2, Discussion on "Methods of Teaching Technical Writing," opened by G. Parr, 6 p.m.——N. MIDLAND CENTRE : The University, Leeds, "Owen Falls, Uganda, Hydro-Electric Development," Sir Charles R. Westlake, R. W. Mountain and T. A. L. Paton, 7 p.m.

Wed., Nov. 10*th.*—RADIO AND MEASUREMENTS SECTIONS : Savoy Place, London, W.C.2, "Standard Frequency Transmissions," L. Essen, "The Standard Frequency Monitor at the National Physical Laboratory," J. McA. Steele, "Standard Frequency Transmission Equipment at Rugby Radio Station," H. B. Law, 5.30 p.m.——N. SCOTLAND SUB-CENTRE : Caledonian Hotel, Aberdeen, "Electricity in the Wool Textile Industry," A. J. Francis and T. H. Carr, 7.30 p.m.——S.E. SCOTLAND SUB-CENTRE : North British Hotel, Edinburgh, "Owen Falls, Uganda, Hydro-Electric Development," Sir Charles R. Westlake, R. W. Mountain and T. A. L. Paton, 6 p.m.

Thurs., Nov. 11*th.*—EXTRA MEETING : Savoy Place, London, W.C.2, "The Overhaul and Maintenance of D.C. Traction Motors," J. G. Bruce, 5.30 p.m.——N. SCOTLAND SUB-CENTRE : Electrical Engineering Department, University College, Dundee, "Electricity in the Wool Textile Industry," A. J. Francis and T. H. Carr, 7 p.m.

INSTITUTION OF ENGINEERING INSPECTION

Tues., Nov. 9*th.*—S.W. BRANCH : Grand Hotel, Broad Street, Bristol, "Purification of Water Supplies," A. H. Waddington, 7.30 p.m.

Wed., Nov. 10*th.*—LONDON BRANCH : Royal Society of Arts, John Adam Street, London, W.C.2, "Current Trends in Diesel Engine Development," R. W. Stuart Mitchell, 6.45 p.m.

INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND

Tues., Nov. 16*th.*—39, Elmbank Crescent, Glasgow, "The Choice of Electrodes for Ship Welding," G. Zoethout, 7.30 p.m.

INSTITUTION OF LOCOMOTIVE ENGINEERS

Wed., Nov. 17*th.*—Institution of Mechanical Engineers, 1, Birdcage Walk, London, S.W.1, "A Modern Hydraulic Drive for Locomotives," R. H. Fett, 5.30 p.m.

INSTITUTION OF MECHANICAL ENGINEERS

To-day, Nov. 5*th.*—INTERNAL COMBUSTION ENGINE GROUP : 1, Birdcage Walk, Westminster, London, S.W.1, "An Experimental Coal-burning Gas Turbine," L. D. Mordell, 5.30 p.m.

Mon., Nov. 8*th.*—SCOTTISH GRADUATES' SECTION : Royal Technical College, Glasgow, Film Evening, 7.30 p.m.——N.E. BRANCH : Stephenson Building, Claremont Road, Newcastle upon Tyne, 2, "An Experimental Coal-burning Gas Turbine," D. L. Mordell, 6 p.m.

Tues., Nov. 9*th.*—AUTOMOBILE DIVISION, GENERAL MEETING : 1, Birdcage Walk, Westminster, London, S.W.1, "The Skid-resisting Properties of Tyres and Road Surfaces," G. Grime and C. G. Giles, "Investigations on the Braking Performance of Road Vehicles," H. J. H. Starks and R. D. Lister, 4 p.m.

Wed., Nov. 10*th.*—INDUSTRIAL ADMINISTRATION AND ENGINEERING PRODUCTION GROUP DISCUSSION : "The British Standard on Drawing Office Practice," 6.45 p.m.——YORKSHIRE GRADUATES' SECTION : College of Technology, Sheffield, "Mechanical Handling," C. A. Brockley, 7.30 p.m.

Thurs., Nov. 11*th.*—N.W. BRANCH : Whitworth Hall, The University, Manchester, "Nuclear Reactors and Power Production," Sir Christopher Hinton, 6.45 p.m.

Fri., Nov. 12*th.*—GENERAL MEETING : 1, Birdcage Walk, Westminster, London, S.W.1, "Inspection, Explosion and Breakdown of Boilers and Pressure Vessels," J. Eyers, 5.30 p.m.

Wed., Nov. 17*th.*—SOUTHERN BRANCH : Brighton Technical College, Brighton, Sussex, "The Future of the C.I. Engine in Small Road Vehicles," J. H. Pitchford, 7 p.m.

INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS

Tues., Nov. 9*th.*—Institution of Electrical Engineers, Savoy Place, London, W.C.2, "Future Demands for Telephone Service : Possible Trends and Reactions," J. M. Norman, 5 p.m.

INSTITUTION OF PRODUCTION ENGINEERS

Mon., Nov. 8*th.*—SHEFFIELD SECTION : Grand Hotel, Sheffield, "Boron Steels," R. Wilcock, 6.30 p.m.——YORKSHIRE SECTION : Hotel Metropole, Leeds, "Men and Machines," J. E. Hill, 7 p.m.

Tues., Nov. 9*th.*—DONCASTER SECTION : Danum Hotel, Doncaster, "Motion Economy," Miss A. C. Shaw, 7 p.m.——OXFORD SECTION : Town Hall, Oxford, "Form in Design and its Influence on Productivity," J. Beresford-Evans, 7.15 p.m.

Wed., Nov. 10*th.*—PRESTON SECTION : Victoria and Station Hotel, Church Street, Preston, "Resistance Welding Fabrication of Small Assemblies," C. A. Burton, 7.15 p.m.——S. ESSEX SECTION : Ilford Bowling Club, Near Ilford Station, Essex, "The Theory and Practice of Spark Machining," A. H. Lines, 7.30 p.m.

Thurs., Nov. 11*th.*—LEICESTER SECTION : Bell Hotel, Leicester, "Production Milling," A. R. Hambidge, 7 p.m.——NORWICH SECTION : Assembly House, Theatre Street, Norwich, "The Work of the Production Engineering Research Association," D. F. Galloway, 7.30 p.m.——N. IRELAND SECTION : Kensington Hotel, Belfast, "Some Aspects of Work Study," L. G. Humble, 7.30 p.m.——ROCHESTER SECTION : Sun Hotel, Chatham, "The Modern Tolerance System," G. J. Pearmain, 7.30 p.m.

INSTITUTION OF STRUCTURAL ENGINEERS

Thurs., Nov. 11*th.*—11, Upper Belgrave Street, London, S.W.1, "Examples of Precast Ferro-Concrete Constructions in France," M. Nesquillan, 6 p.m.

Fri., Nov. 12*th.*—WESTERN COUNTIES BRANCH : University Geology Lecture Theatre, Bristol, "Unusual Industrial Structures," H. C. Husband, 6 p.m.

INSTITUTION OF THE RUBBER INDUSTRY

Thurs., Nov. 11*th.*—LONDON BRANCH : Institution of Civil Engineers, Great George Street, Westminster, London, S.W.1, "Nitrile Rubbers," E. J. Buckler, 6 p.m.

INSTITUTION OF WATER ENGINEERS

Wed., Nov. 10*th.*—Institution of Civil Engineers, Great George Street, Westminster, London, S.W.1, "Geology as Applied to Agricultural Land Drainage and Farm Water Supply," W. H. E. Rivett, "The Water Engineer and Higher Productivity," A. J. Chanter, 2.30 p.m.

IRON AND STEEL INSTITUTE

Wed. and Thurs., Nov. 17*th and* 18*th.*—4, Grosvenor Gardens, London, S.W.1, Autumn General Meeting.

JUNIOR INSTITUTION OF ENGINEERS

To-day, Nov. 5*th.*—Pepys House, 14, Rochester Row, London, S.W.1, Film Evening, E. A. Applebee, 7 p.m.

Mon., Nov. 8*th.*—SHEFFIELD AND DISTRICT SECTION : Livesey Clegg House, Sheffield, President's Address, "The Nation's Water Supply," J. Noel Wood, 7.30 p.m.

Fri., Nov. 12*th.*—ORDINARY MEETING : Pepys House, 14, Rochester Row, London, S.W.1, "Corrosion," W. F. Gerrard, 7 p.m.

LIVERPOOL ENGINEERING SOCIETY

Wed., Nov. 10*th.*—24, Dale Street, Liverpool, "The Winning of Petroleum," J. A. C. King, 6 p.m.

LIVERPOOL METALLURGICAL SOCIETY

Thurs., Nov. 18*th.*—Liverpool Engineering Society, The Temple, Dale Street, Liverpool, "The Fracture of Metals," C. E. Phillips, 7 p.m.

MANCHESTER ASSOCIATION OF ENGINEERS

Fri., Nov. 12*th.*—Engineers' Club, Albert Square, Manchester, 2, "A Brief Survey of the Early History of Woolwich Arsenal," O. F. G. Hogg, 6.45 p.m.

NEWCOMEN SOCIETY

Wed., Nov. 10*th.*—Annual General Meeting : Institution of Civil Engineers, Great George Street, Westminster, London, S.W.1, "Far Eastern Engineering," H. Chatley, 5.30 p.m.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS

Fri., Nov. 12*th.*—Mining Institute, Newcastle upon Tyne, "Instrumentation in Engineering Research with Particular Reference to Marine Turbine Machinery," B. J. Terrell, 6.15 p.m.

ROYAL AERONAUTICAL SOCIETY

Thurs., Nov. 11*th.*—Main Lecture : Institution of Mechanical Engineers, 1, Birdcage Walk, London, S.W.1, "Boundary Layer Control," G. V. Lachmann, 6 p.m.

SHEFFIELD SOCIETY OF ENGINEERS AND METALLURGISTS

Tues., Nov. 16*th.*—B.I.S.R.A., Hoyle Street, Sheffield, "Specifications : Friends or Foes ?" S. Barraclough, 7 p.m.

SOCIETY OF CHEMICAL INDUSTRY

Tues., Nov. 9*th.*—Geological Society, Burlington House, London, W.1, "The Decoloration of Sugar Liquor by Solid Absorbents," H. C. S. de Whalley, 5.30 p.m.

Fri., Nov. 12*th.*—Technical College, Tavistock Road, Plymouth, Joint Meeting of the S.W. Section and the Corrosion Group, General Discussion of Practical Corrosion Problems, 3 p.m. to 4.45 p.m., and 5.30 p.m. to 7 p.m.

Thurs., Nov. 18*th.*—Institution of Structural Engineers 11, Upper Belgrave Street, London, S.W.1, "The Constitution and Structure of Coal Tar Pitch," L. J. Wood, 6 p.m.